MACHINERY.

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A RAILROAD TESTING LABORATORY.

WM. O. WEBBER.

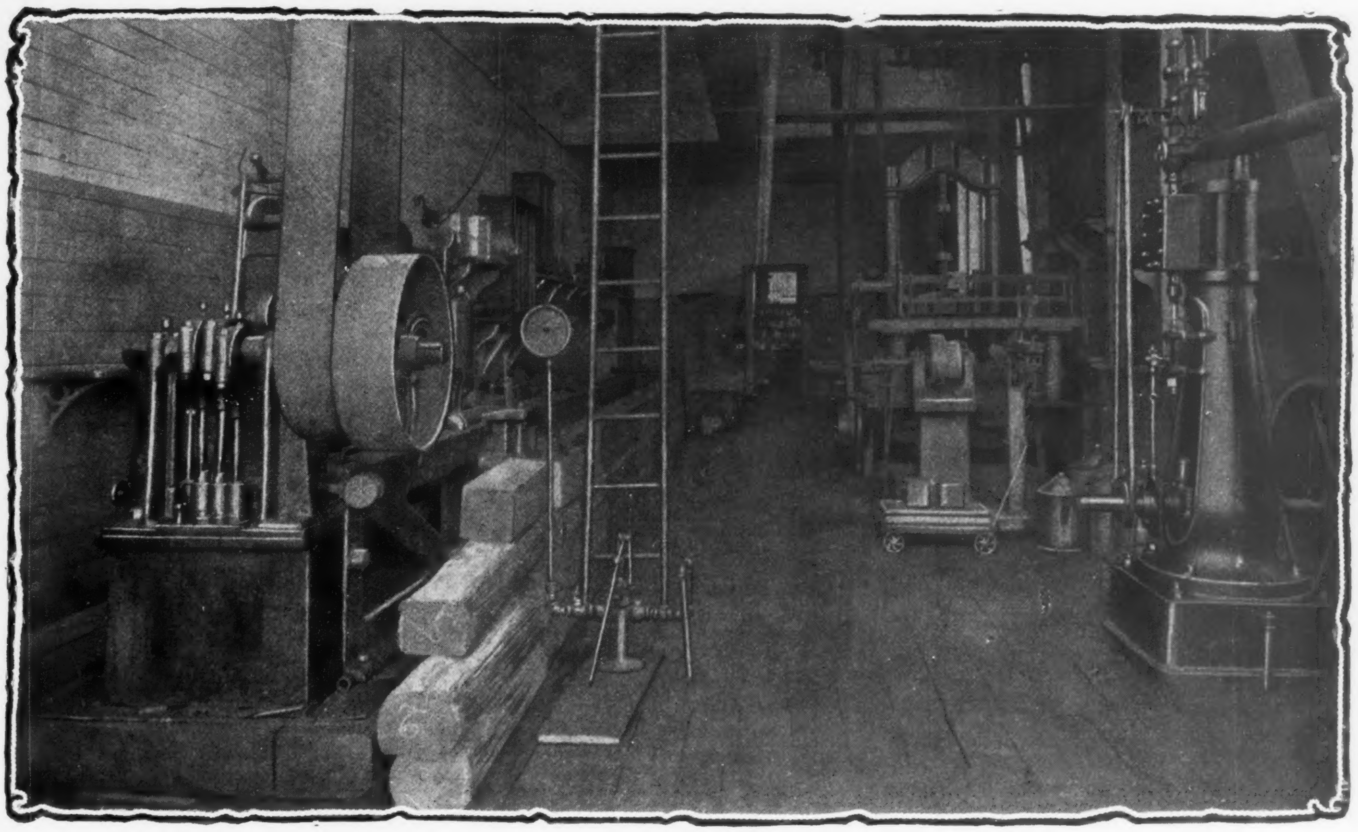
IT should be pretty generally understood by this time that the testing of materials in such a laboratory as the one illustrated, is done for the purpose of determining the value of articles being tested as compared with pre-determined standards, and is largely done for the purposes of insuring that the materials furnished to the company are up to a regular standard of excellence, or else the detection of sufficient foreign substances or inferior material and workmanship as to either prove adulteration or carelessness in their manufacture. Such a laboratory is merely intended to be a safeguard to the shop and other departments using materials to ascertain whether the materials furnished are up to the standard specification.

The Chicago, Burlington & Quincy R.R. laboratory, at Aurora, Ill., of which the accompanying photographs are illustrations, was first established by the writer in the fall of 1876 under the directions of Mr. C. M. Higginson, at that time purchasing agent of the "Q" but now assistant-president of the Atchison, Topeka & Santa Fe R. R.

This laboratory was started by having a Taglibue pyrometer for the purpose of ascertaining the flash and fire test of petroleum oils, on one side of the writer's drawing-board. To this was then added an Ashcroft Oil Testing Machine, which was kept in the engine room of the car shops. On this small beginning the laboratory grew, as shown by the photographs.

In the big Riehle Testing Machine shown, which has a capacity of 300,000 pounds and is 65 ft. long, were tested bridge bars up to 40 ft. long. This test consisted in ascertaining the elastic limit for the purpose of knowing that rods were of the required material and workmanship to carry their load well within factor of safety, and also ascertain whether the workmanship of any bridge was up to the required standard. In buying a bridge the "Q" road required the contractor to furnish enough bars to make an extra panel for the bridge. The whole bridge, with the extra parts, was then loaded on cars and when they arrived at the laboratory the whole bridge was inspected and a set of bars selected at random. These were then tested to destruction, and were then held to be a fair average of the remainder of the bridge of which, of course, there was enough left to complete the whole.

The boiler plate which was received by the road had a coupon left attached when sheared at the mill, and this was numbered to correspond with the sheet with ½ inch steel figures. This coupon was cut into a tensile sample 9 in. long and one each for cold, hot and chilled bending 5 in. long. The 9 in. tensile sample was reduced in the center to 4 in. between the shoulders and all percentages of elongation were considered with a 4 in. standard. The bending samples had their edges dressed to remove the wire edge caused by the shears, and were first bent to about 4 in. radius under a small hammer which was used as a press, until it assumed the shape of a letter U. Afterwards the parts were shut down tight by light taps from the hammer. The tensile test was of course taken to ascertain the ultimate strength of the sheet. The measurement of elongation and the cold bending test were made to ascertain the ductility of the materials; the hot bending test was made to ascertain whether there was sufficient phosphorus to make the metal "red-short" and so be difficult to flange, and the chilled test was made to ascertain whether the sheet would be liable to crack in service, by the "blowing out" of the boiler hot and filling it up with cold water.



C., B. & Q. R.R. LABORATORY. 300,000 LB. RIEHLE TESTER. 100,000 LB. FAIRBANKS TESTER. THURSTON OIL TESTER.

When steel first came into use for locomotive boilers, fully 50 per cent. of the sheets failed in service, so that at one time steel was practically condemned for locomotive boiler service on the railroads in the Mississippi Valley, but by reason of these tests

and careful records being kept of the same and the life of the sheets in actual service, both the road and the steel makers found out the quality of the steel required for this service, and I have no hesitation in saying that the failures do not amount to over 2 per cent. at the present time.

The Thurston Oil Testing Machine, which is standing on the floor just in front of the Fairbanks Machine, was used to determine the value of lubricating oils, and consisted in running a small, accurately gauged, amount of oil on this machine, whose journal was of the same dimensions as a standard car axle journal and with a load which represented the average load on such an axle, until the temperature was raised from 80 to 200 degrees F., and the length of time and total number of revolutions were noted for two consecutive tests which were compared with similar tests of standard winter strained lard oil, and of which similar tests were made immediately following the test of the oil under consideration, thus enabling the elimination of such conditions as temperature and humidity of atmosphere. The specific gravity, flash and burning and freezing tests, were made in the chemical laboratory, in the little closet in the further corner of the writer's desk. The specific gravity test was made to determine whether the oil had sufficient body for the work to be done; the flash and burning tests were made to prevent "hot boxes" on the road, and the freezing tests were made to ascertain that the oil would not become solid so as to refuse the flow through oil can spouts and other oil holes during our usual coldest weather in the winter.

The chemical laboratory was largely used in the testing of coals to determine their relative values. Coals which had too large a per cent. of sulphur would clog the grates up and make large clinkers in the fire. Coals having an unusual amount of volatile carbon made an unnecessary amount of smoke, and the extreme draught of the locomotive by reason of the exhaust, wasted a large amount of their carbon. Those coals which had the least amount of sulphur and the largest amount of fixed carbon were the ones which did the most work on the roads and did the least damage to the grates and fire-box sheets of our boilers.

The different waters along the road were also tested to ascertain their purity. Those containing the least amount of lime in both mechanical and chemical tests were the best to use, because they kept the boilers cleaner and consequently gave better steaming efficiency and made less deposit in the water legs around the fire boxes, and consequently less liability of burning out the firebox sheet at that point.

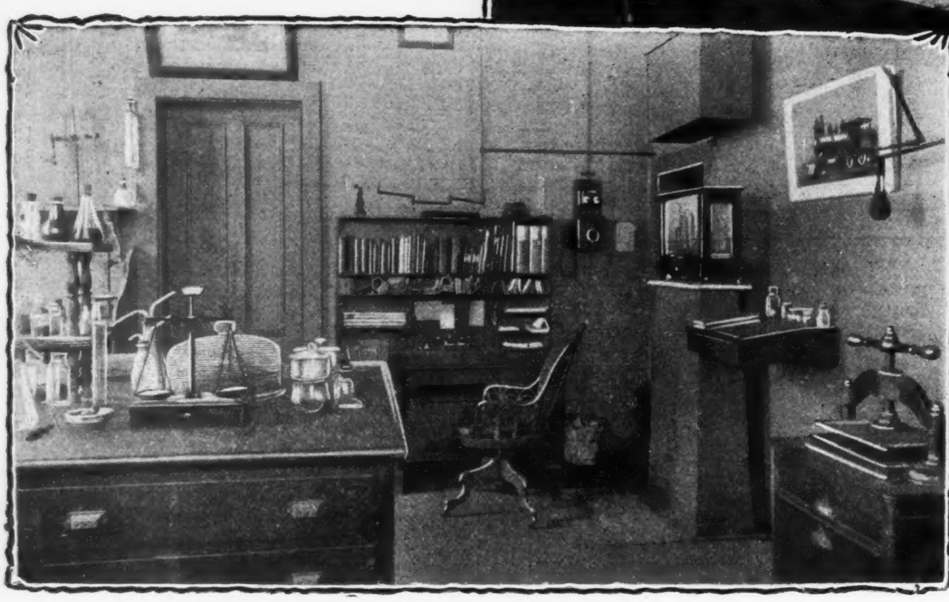
The inspection of paints, soaps and other materials used in the paint department of the road, formed another quite important branch of the chemical laboratory work. These tests were largely reduced to a system so as to economize time and result in large practical benefit. Thus, samples of white lead which showed the largest percentage of carbonate of lead, give the best wearing qualities on the road, also those samples which contained the least amount of silver, kept their color and did not turn brown by being exposed to the sulphurous smoke which is always present in the western bituminous coals.

* * *

THE AMERICAN SOCIETY OF MECHANCAL ENGINEERS.

The largest meeting ever held by this society closed its four days' session, Friday, December 4th, with 556 names on the register. We have selected such papers as seemed likely to interest the readers of this paper, and condensed these as much as possible, giving the information and conclusions in their plainest form. A few others may appear in February.

CHEMICAL LABORATORY.



OFFICE OF ENGINEER OF TESTS.

Policeman's club on desk kept for Chicago men who asked too many questions.

THE MANUFACTURE OF IRON AND STEEL IN AMERICA.

(EXTRACTS FROM PRESIDENT FRITZ'S ADDRESS.)

GENTLEMEN: Prior to 1838 the manufacture of pig iron was in a primitive condition, that metal being practically all made in charcoal furnaces, producing from fifteen to thirty tons per week, and was converted into wrought iron in the old-fashioned charcoal fires, then was shaped into blooms for the rolling mill, and into bars for the smith by a helve hammer. The furnaces, forges and mills were all driven by water power, and were kept in order by what was sometimes called a forge carpenter, or millwright. At this time the mills were all geared, the shafts being square, hexagon, or octagon, according to the fancy of the millwright; the wheels were secured on the square shafts by wooden blocks, and in them were driven thin iron wedges; the segments of the wheels were secured to the center in the same manner; the roll housings were all set on wood. All this crude machinery the millwright was called on to keep in running order; consequently he became an important man.

In 1840 the use of anthracite coal and coke in blast furnaces was commenced. This required a much higher pressure of blast. Previous to this time the blowing cylinders had been made out of wood, the pressure of blast being very low, not exceeding one and a half pounds; hence a great improvement in blowing machinery became necessary.

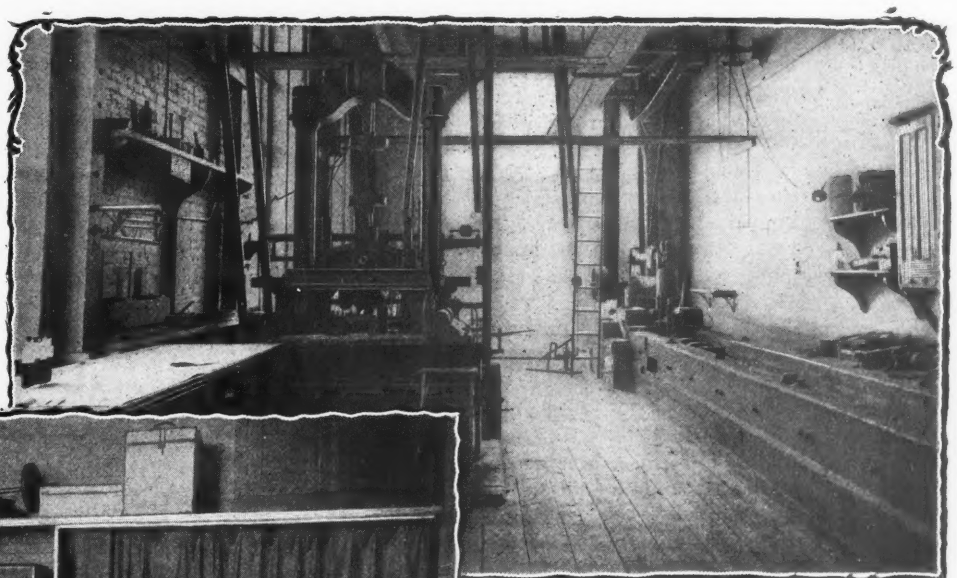
In 1842 puddling began to come into more general use, then

puddling trains had to be built, and better merchant or bar trains were now required; they were all geared, and gave much trouble. The machinist now had to be called in to help keep things in shape, and he soon took the millwright's place, and laid the foundation for the mechanical and metallurgical engineer.

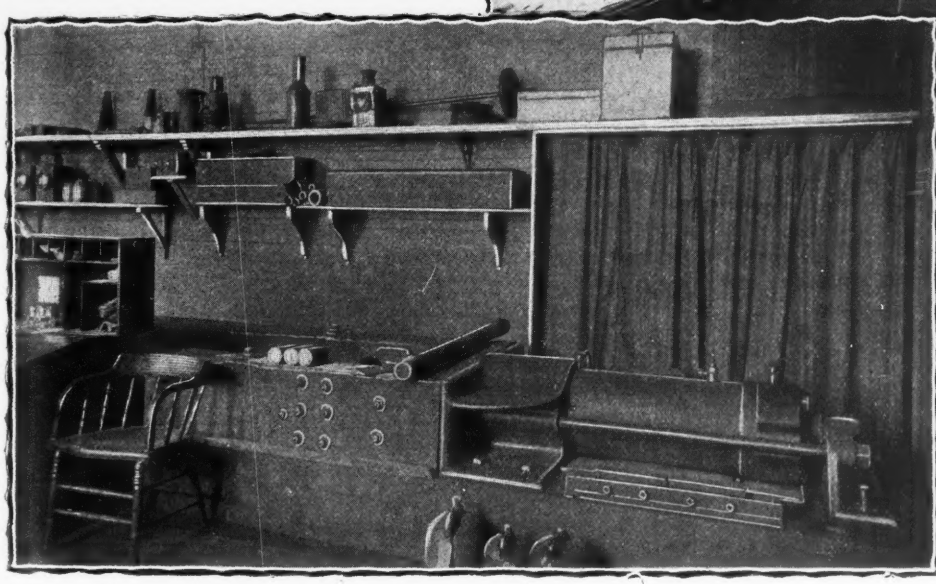
In 1845 the rail mills were being built, and stronger and better workmanship was required.

In or about the year 1848 "boiling" came into use, which was a great improvement over ordinary "puddling," and gave a new impetus to the trade. From 1848 to 1856 there was no great change, or marked improvements made in the business. In 1857 the three-high rail mill was successfully introduced, and in a very short time practically revolutionized the manner of rolling rails. From this time on, all the new mills that were built were driven direct, without gearing, and much stronger and better in every way. This was an advance for the mechanical engineer, and prepared him for the great work that he was soon to be called on to accomplish.

In 1864 the Bessemer process was introduced, and it soon became evident that it would in a short time revolutionize the iron business. Its introduction and perfection will ever remain one of the most interesting and important epochs in the whole history of the iron business. It was now that the men that had been in training were called to the front, and nobly did they do their duty. This was the graduating period for them, and no set of men ever worked more faithfully or earned their diplomas more honestly than these men did. Their diplomas were not made of parchment, but of bright ideas, hard work, and energy, coupled with a determination that made failure impossible.



GENERAL VIEW OF TESTING MACHINES.



HEAD OF REIHLE 300 000-LB. TESTING MACHINE, C., B. & Q. LABORATORY.

I do not propose to give you a yearly array of statistics; but in 1895 the production reached the enormous quantity of 4 909 128 tons of ingots. In the same year the production was of puddled iron 3 500 000 tons, making a total of steel and puddled iron, 6 409 128 tons.

In order to show what the Bessemer process can do in coal and labor, as compared with puddling, the former can produce in ten minutes ten tons of steel ingots, with a consumption of twenty hundred of coal. It will require a puddling furnace ten days, with practically three men, to produce a like amount of puddled iron, and will require about twenty tons of coal. The puddling is a hard, laborious, and exhausting occupation. With the Bessemer it is care and attention only, but that it must have.

We left the blast furnaces in 1840, making fifteen to thirty tons per week, and producing in that year 286 903 gross tons. In 1895 we have furnaces producing between two and three thousand tons per week, and others building that are expected to make much more. The total output in 1895 was 9 446 308 gross tons, which exceeds the quantity made by any other nation.

In 1866 the Siemens open-hearth furnace for making steel was produced, but it was some time before it came into general use; the Bessemer for quite a while held it in check. To-day it occupies an important position, and, in connection with the Thomas basic process, one of the great metallurgical inventions of the age, is sure to become a strong competitor of the Bessemer process. When I allude to the Siemens open-hearth furnace I do not mean that their form of hearth and ports should be strictly adhered to, as there are other styles of furnaces which have their advocates; amongst them are the partial revolving hearth, which so far has shown good results, and it certainly has advantages over the fixed hearth. What I refer to is the Siemens regenerative principle, which is truly scientific and yet perfectly simple in its construction, and so far is the only method by which the metallurgist has been able to secure the heat necessary for making steel on the open-hearth plan; and all steel-melting furnaces, of whatever form the hearth has been constructed, use the Siemens regenerative principle. Much as I admire the Bessemer process and well know what can be accomplished with it, yet, if the users of steel insist on lower phosphorus, it will have to be made in the open hearth, and by the Thomas basic process, as the ores that will make steel of high grade by either of the acid processes are, so far as known, quite limited.

Having given you a very brief account of the progress of the iron and steel industry from its infancy up to the enormous production in 1895, I shall now endeavor to show the wonderful changes that have been made in machine tools and shop practice. My memory of machine shops dates back to 1832 and 1833. Within a short distance of my home there were three cotton mills (and large ones for those days), two woolen, and two carding mills, and several grist mills, as they were called at that time. At one of the large cotton mills they had a machine shop, where the principal repairs for all the mills in the neighborhood were generally made. My father, being a millwright and machinist, as well as a small farmer, did all the important repairs for all the mills; in this shop consequently I spent all the spare time I could get off the farm, and it was a rare treat for me to get there. The tools consisted of two small lathes for turning iron and one for turning wood; all of them had wooden "shears" or beds. There was also a machine for cutting light gears, which to me was a great curiosity; there were several vises, and quite a number of small tools; one they called a "doctor," which was used to correct "drunken threads," as all screws of any importance were cut with the chaser. A few years later I frequently wished I had one of them to straighten up some crooked threads.

In 1846 I became connected with a bar mill, and practically the only tool they had was a roll lathe with the old-fashioned fixed rest, and the tool was regulated by keys driven with a chipping hammer. After a time, with a good deal of persuasion and some strong talk, I succeeded in getting some small lathes, a planer, and a press drill. About this time some of the larger iron works put in some better tools, but they were all small. Indeed, up to this time about all the tools we had were a two-hand chisel, a sledge, a chipping hammer and a chisel, a file, and a ratchet drill. The mills all being geared, we had a set of drifts to suit the key-ways in the various wheels and shafts.

In 1854 I went to the Cambria Iron Works at Johnstown, and well knowing the importance of having good tools for the completion and perfection of such a plant as that was intended to be, I earnestly urged the company to get some of the best tools that were built, which they consented to, and at the same time had some special lathes built, and made much heavier than any that had been previously designed. This was the commencement of a better class of tools about the iron works, and greatly facilitated the marked improvements which soon after took place. But this is over forty years ago, and what was a good tool at that time is a very indifferent one to-day, as the machine-shop equipments have fully kept pace with the times.

I look back to my early days in the shop, now nearly sixty years ago, and call to my mind the equipments of the shop in the way of tools which I have already described, and compare the facilities for making drawings of to-day with those at that time, when the complete outfit consisted of a board, a carpenter's square, a pair of compasses (as we then called them), a bevel, a lead pencil, and a piece of chalk, and a jack plane to prepare the board for another drawing. After a time we adopted the plan of making models in skeleton, full size, especially when any motion was to be worked out, and also made, when it was possible, all the drawings full size; when too large to admit of this, would make important sections full size, and this practice I am not ashamed to follow at the present time, as it has many advantages.

The small shop tools for a lathe consisted of a hook tool with a sharp tit on the bottom to hold it on the rest (which was made of soft wrought iron); the tool was made out of a steel bar about ½ by ¾ inch. generally put in a wooden stock some 2½ inches in diameter, with a handle on the lower side. In addition to the tool just described, there was a finishing tool made in the shape of a spike-head, cutting edge on both sides, one to do the cutting or finishing, and the other to keep it in position on the rest; it also had a wooden handle, but of different construction from the handle of the hook tool, as it was held against the shoulder instead of under the arm; next was a chaser, and last, as usual, was the "doctor," to cure in a measure "drunken threads," which frequently occurred. The small tools consisted of a pair of outside and an inside pair of calipers, a file, and a steel straight-edge (home-made), 12 inches long, and was divided into inches, ½ inch, ¼ inch, ⅛ inch, $\frac{1}{16}$ inch, and one of the inches was divided into 32ds, and was used for measuring, as well as for a straight-edge.

Now let us for a moment note the equipments of a modern machine shop for comparison. First, they have a great drawing room, and a good corps of men well skilled in their art, and are equipped with everything that is essential for producing work correctly and quickly, with blue prints by the score The machine shop of to-day is a marvel in completeness of equipments for doing work correctly and with rapidity, having special small tools for all purposes. The accuracy with which their round gauges are fitted up is such that a machinist of fifty years ago could not possibly realize how it could be done. Suppose you could have in his presence separated a one-inch gauge, and held the plug in your hand for a few moments, without calling his attention to it, then hand it back, and request him to put it in its place again, and find he could not get them together, he would think there were some old-time witches about.

To those persons who were using steel low in carbon, for various purposes, I would urge the use of a higher grade of steel, well knowing it would answer their purpose better; but was answered by some that it required too high a grade of skill to utilize it; they must have a material that any one could handle, consequently the steel was so low in carbon that it was no better than iron, and in many instances not as good. My own early experience having fully convinced me that nearly all the failures were due to the use of improper kind and grade of steel, being too low in carbon, and in most instances so high in phosphorus and sulphur that nothing but failure could be expected, yet it was useless to attempt to convince them that a higher-carbon steel of proper analysis would answer their purpose. They said no; "we are going back to iron; we know what that is, and we can trust it."

There are some people who contend that the presence of phosphorus to an extent not in excess of twelve one-hundredths (.12) will do no harm in low steel, and I have been told quite recently that a person who posed as a mechanical engineer, and a steel maker, endorsed that position; and he may be both, but I will take this occasion to put myself on record by saying that I have no use for it in any shape or form whatever, and by keeping it low you can increase the carbon, which is in the right direction for good steel.

The subject of hollow forgings being one in which the mechanical engineer is more or less interested, I will give a brief description of the process, and how the ingot is prepared. Having already told you that the metal is subjected to pressure while in a fluid condition, I will now commence with a cold ingot. It is first examined externally, and if there are no imperfections visible it is then put into a powerful lathe, and after the proper discard is cut off it is then cut to the proper length, that being determined by the final weight of the forging it is intended for. Next it goes to the boring mill, and is bored out to a size corresponding to the diameter of hole in finished forgings. You now have the ingot (or such part as you want) in the best possible shape for examination; and this is not all, for the centre of the ingot is always the most undesirable part of it, and the boring of the hole gets it out of the way entirely. We now have it in the most desirable condition possible for the heating furnace, where it next goes, and it is in the heating that it is exposed to its greatest danger, and where skill and the greatest possible care are required, and it must be charged in a cold furnace, which should be a pre-heating furnace, and heated up slowly until the heat reaches the centre; it is then taken to the forge furnace, and heated slowly and regularly (in order to prevent internal strains), until it reaches the proper temperature for forging. The higher the carbon the more care is required, especially in the first heating, it being the crucial test, and where the damage is generally done, and if once done, it cannot possibly be repaired. When it is finally brought up to the proper heat it is taken to the press, and a mandrel is put in, and the forging commenced, and this part of the operation requires skill, sound judgment, and great care to see that it is worked at the proper heat, and in a manner that will not produce any undue internal strains, and in irregular forgings special care must be taken in shouldering down and in working up flanges or projections, in order to prevent "fins," or excrescences, from forming, that may be unnoticed work into the body of the forging. One of the great advantages of hollow forgings over solid is that by boring out the centre of the ingot the metal is reduced to less than one-half the thickness of the solid forging, and by using the press, the action being slow, the ends of the forging are convex, showing that the force of the press had reached the centre of the metal, while the hammer strikes a quick and sharp blow, affecting the outside of the metal to a much greater extent than the inside or centre, consequently the end of the forging is concaved, showing at once the superiority of the press over the hammer. There are other advantages in the use of the press for forging purposes, but time will not permit a proper description of them.

In 1810 Isaac Pennock built a mill near Coatesville, Chester County, Pa., and it is claimed that the first boiler plates that were made in this country were made in this mill. The plates were made from a single charcoal bloom, the bloom being made in an old-fashioned charcoal fire—pig metal. The blooms were re-heated on an ordinary grate fire and rolled into plates, and were shipped without being sheared. There were no railroads in those days. Coal was hauled from Columbia, distance 36 miles. The plates were teamed to philadelphia, 35 miles distant, and to Wilmington, 26 miles. Some of the older members of this Society will doubtless remember that in old times the boilers were small in diameter and narrow sheets. This came from the fact that they heated the blooms on a grate fire, and there being no reverberatory furnaces at that time in this country, could not be doubled; consequently the size of the plate was limited to the size of the bloom. The rolls were small, and short of power to drive them. This mill has been rebuilt three or four times within my recollection. To-day they have open-hearth furnaces for making steel, and can roll plates 119 inches wide and of great length. One

thing quite remarkable about these works: it has always remained in the family of Isaac Pennock, and is at this time controlled by his descendants.

FRICTION HP. IN FACTORIES.

This interesting subject concerning the small economies on which so much depends in these days of close competition, was ably treated by Prof. Benjamin, of the Case School of Applied Science, Cleveland, O. The data given was secured from observations in sixteen different plants, including rolling and stamping mills, general machine work and screw factories.

Indicator cards were taken hourly from the engine during the day, while the plant was running full, and other cards taken after hours, when only line and countershafts were running. Averages of these were assumed to show the total HP. and friction HP. For heavy machine work the average power to drive shafting was 62.3 per cent.; light machine work, 55.1 per cent.

Average HP. per bearing, heavy machinery	.567
" " " " light	.428
" " " 100 feet of shafting, heavy machinery	5.57
" " " " " " " light "	4.83
" " " " lbs. of shafting, heavy "	.22
" " " " " " " light "	.309

One shop, making steel wood screws, gave remarkable results, owing largely to shafting being in excellent alignment, supported by exceptionally rigid hangers and running in cast iron boxes instead of babbitt lined. The oiling was also mostly done by hand instead of depending entirely on wick feed. This shafting consumed but 14.5 per cent. of the power, .178 HP. per bearing, 2.53 HP. per 100 feet of shafting and .109 HP. per 100 pounds of shafting.

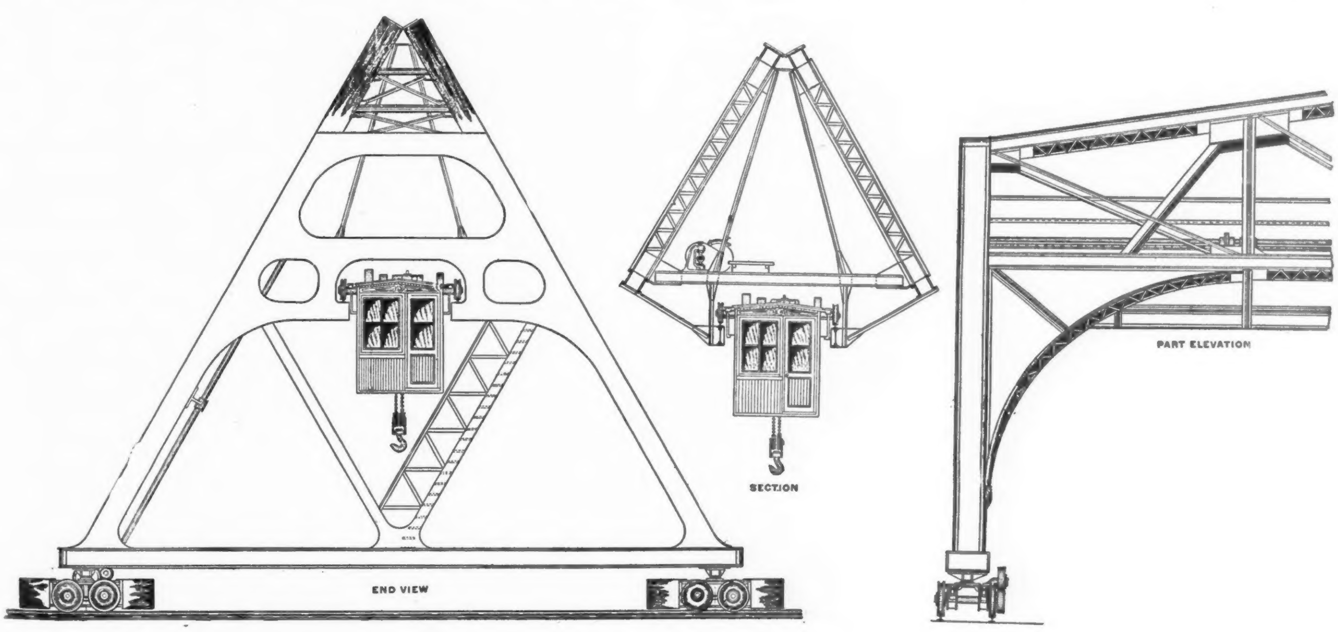
The conclusions drawn are that losses of 55 to 65 per cent. of power generated by engine are unnecessary, and that poor alignment, insufficient support of shafting and inferior oils are largely responsible, and the following suggestions are made:

1. Use pulleys of large diameter on counters and narrow fast-running belts.
2. Use nothing but the best oil and plenty of it, catching all drip, and either purifying it or using it for some other purpose.
3. Have all the shafting and counters oiled regularly, and do not depend too much on automatic oiling.
4. Inspect line shafts from time to time, and see that they are in line and can be turned easily.

See that line shaft boxes do not bind at the sides when screwed down, this sometimes increases the turning moment a hundred per cent.

A 200-FOOT GANTRY CRANE.

Some of the details of this large crane, designed by the Wellman-Seaver Engineering Co., Cleveland, O., are interesting, and together with the illustrations, will show its main features quite clearly. There are two cranes, each of 200 feet span, running on surface tracks, this covering a yard 400 feet wide by 800 feet long, and of sufficient height to allow a train to pass underneath, making the crane 21 feet 2½ inches in the clear. From center to center of trucks is 49 feet 9¾ inches. The trucks are designed to carry 48 000 pounds distributed on four wheels, which are spaced about 9 feet between centers.



200-FOOT GANTRY CRANE.

The minimum speeds of the various motions of the crane are as follows:

Traverse of main bridge	200 feet per minute.
" " trolley	400 " " "
Hoist with full load	20 " " "

The crane rests upon four trucks; each having four steel tired double flange wheels, 24 inches in diameter. The wheels are keyed to steel axles, 5 inches in diameter. The gauge of the track is 3 feet 6 inches centers of rails. The journals are 5 inches in diameter, 7 inches long, fitted with bronze bearings carried in cast-steel oil-boxes, with ample provision for lubrication. The wheels on one truck at each end are connected by means of a system of shafts and beveled gear wheels. The gear wheels are steel castings, and are of extra heavy design throughout. The shafting from one truck to the other is 4 inches in diameter. The couplings are all rigid flanged couplings, tightly keyed to the shafts, and fitted with turned bolts of a tight driving fit. The main shaft, extending the length of the crane, is carried in universal bearing pillow-blocks of very heavy design. These pillow-blocks are bolted to the cross beams of the floor system, with packing pieces between them and the beams, and are lined up perfectly true and level. The thickness of the packing pieces vary to suit the requirements of each individual pillow-block.

The end frames are so arranged that should it be desired to transfer a load from one side of the yard to the other, both cranes can be brought in line with each other by means of removable stops on the trucks, and the trolley from either crane run directly through the end supports and on to the track on the other crane.

PAPER FRICTION WHEELS

Friction wheels have long been used, but apparently without much data as to results, and the paper on the above subject by Prof. Goss, of Purdue University, Lafayette, Ind., was full of interest and suggestion. The driven wheel is usually of cast iron, and driver of some yielding material to give a high coefficient of friction, and so that in case of slippage the softer driver will inflict no injury to the driven wheel.

The results of careful experiments with friction wheels (made of layers of straw board cemented together and held by iron plates) 5½, 8, 12 and 16 inches in diameter in contact with a cast iron wheel 16 inches in diameter. Contact pressure was varied from 75 to 400 pounds per inch of width, with surface speeds of from 450 to 2 700 feet per minute, and the data is the result of over 5 000 observations.

Slippage can be increased to 3 per cent., which gives about the maximum coefficient of friction. The coefficient gradually rises from .14 at 1 per cent. to .205 at 3 per cent., from this to 6 per cent. the coefficient increases slightly, but extreme slippage,

even to stoppage of driven wheel, is liable to occur. This is practically constant for wheels of 8 inches diameter and over, and also for all pressures of contact up to a limit which lies between 150 and 200 pounds per inch width of wheel face; beyond this the value decreases, being 10 to 15 per cent. less at 400 pounds pressure than for 150 pounds. Smaller wheels give a lower coefficient of friction, while variations in surface speed between 400 and 2 800 feet do not affect it.

By making D the diameter of the friction wheel in inches, W the width of its face also in inches, andN the revolutions per minute, and by accepting 0.2 as a safe value for the coefficient of friction, and a pressure of 150 pounds per inch width of face as the pressure of contact, the horse power may be written thus:

$$\text{HP.} = \frac{150 \times 0.2 \times \frac{1}{12} \pi D \times W \times N}{33\,000} = .000238\ D\,W\,N.$$

This formula is believed to be safe for friction wheels which are 8 inches or more in diameter, and under conditions which make it impossible for them to be kept reasonably clean. By its use the following table has been calculated:

HORSE POWER WHICH MAY BE TRANSMITTED BY MEANS OF A CLEAN PAPER FRICTION WHEEL

OF ONE INCH FACE WHEN RUN UNDER A PRESSURE OF 150 POUNDS.

Diameter of Pulley.	Revolutions per Minute.						
	25	50	100	200	400	800	1000
4	.0238	.0476	.0952	.1904	.3808	.7616	.9520
6	.0357	.0714	.1428	.2856	.5712	1.1424	1.428
8	.0476	.0952	.1904	.3808	.7616	1.5232	1 904
10	.0595	.1190	.2380	.4760	.9520	1.9040	2.380
14	.0833	.1666	.3332	.6664	1.3328	2.6656	3.332
16	.0952	.1904	.3808	.7616	1.5232	3.0464	3.808
18	.1071	.2142	.4284	.8568	1.7136	3.4272	4.284
24	.1428	.2856	.5712	1.1424	2.2848	4.5696	5.712
30	.1785	.3570	.7140	1.4280	2.8560	5.7120	7.140
36	.2142	.4284	.8568	1.7136	3.4272	6.8544	8.568
42	.2499	.4998	.9996	1.9992	3.9984	7.9968	9.996
48	.2856	.5712	1.1424	2.2848	4.5696	9.1392	11.424

Fig. 2.

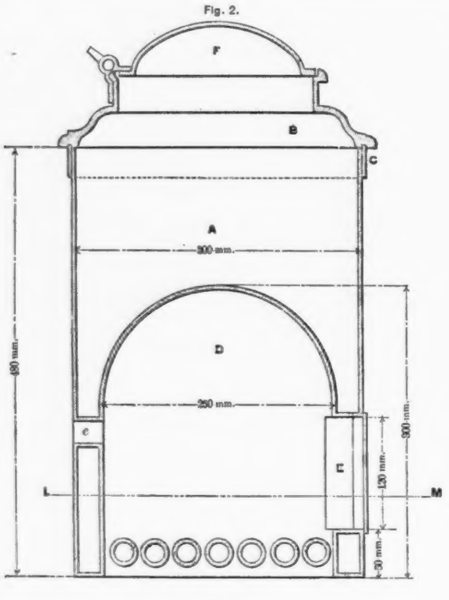


Fig. 5.

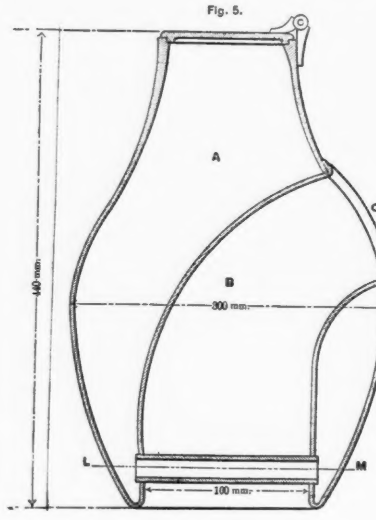
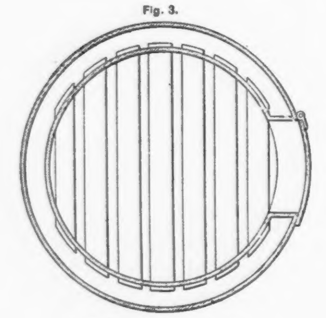
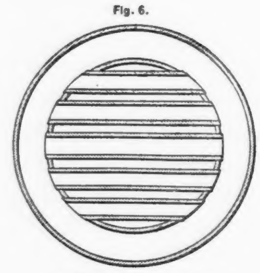


Fig. 3.



SECTION THROUGH L M

Fig. 6.



SECTION THROUGH L M

ANCIENT POMPEIIAN BOILERS.

ANCIENT POMPEIIAN BOILERS.

That there is little, if anything, absolutely new under the sun, seems to be illustrated in this paper, by W. T. Bonner, Cincinnati, O. The entire paper is interesting, but a few of the boilers only can be mentioned.

The illustrations were furnished by M. Francisco Milone, a Neapolitan engineer, and bear a very close relation to the water leg, water grate and water tube boilers of to-day. Figs. 2 and 3 show a boiler with both a water leg and water grates.

No evidence of connection to a chimney is shown, but as the Pompeiians used charcoal as fuel, there was probably little annoyance from gas or smoke. Figs. 5 and 6 show another form of boiler having the same principles.

Photographs of these boilers show clearly the artistic tastes of the ancients, for nearly every part, no matter how simple, is decorated in an attractive manner. But that was before the days when dollars and cents governed the production of mechanical devices as closely as at present.

REPORT OF THE COMMITTEE ON FIRE-PROOFING TESTS.

While this is interesting to engineers dealing with structural material and similar work and shows much labor on the part of the committee, it is not a subject of special interest to mechanics generally, and a list of the tests made is all that is given.

First.—A series of tests on steel and on cast-iron columns, without any fire protection whatever. These tests to be taken as basis of comparison with those that follow.

Second.—A series of tests with similar steel and cast-iron columns, protected with different materials and in different manner.

Third.—A series of tests on unprotected beams and girders.

Fourth.—A series of tests on unprotected beams and girders.

It has also been proposed that each series be divided for test both with and without water.

SPECIAL FORMS OF COMPUTERS.

Under this heading, Mr. F. A. Halsey, associate editor of the *American Machinist*, calls attention to the usefulness of mechanical devices for computing such problems as strength of gear teeth, beams, horse-power of engines and boilers, areas of safety valves, and weights on levers, etc. He showed how, by the use of these calculators, formulas with any reasonable number of factors can be readily solved with very little trouble and with hardly a chance for error.

THE NEW OFFICERS.

The newly elected officers of the American Society of Mechanical Engineers, represent various branches of engineering. Mr. Worcester R. Warner, who succeeds Mr. John Fritz as president, is one of the best known men in the machine tool trade, the firm of Warner & Swasey, Cleveland, Ohio, being in the foremost rank of tool buiders as well as having a world-wide reputation as makers of mountings for the larger telescopes. Mr. Warner's thorough mechanical training and genial manner have won him hosts of friends.

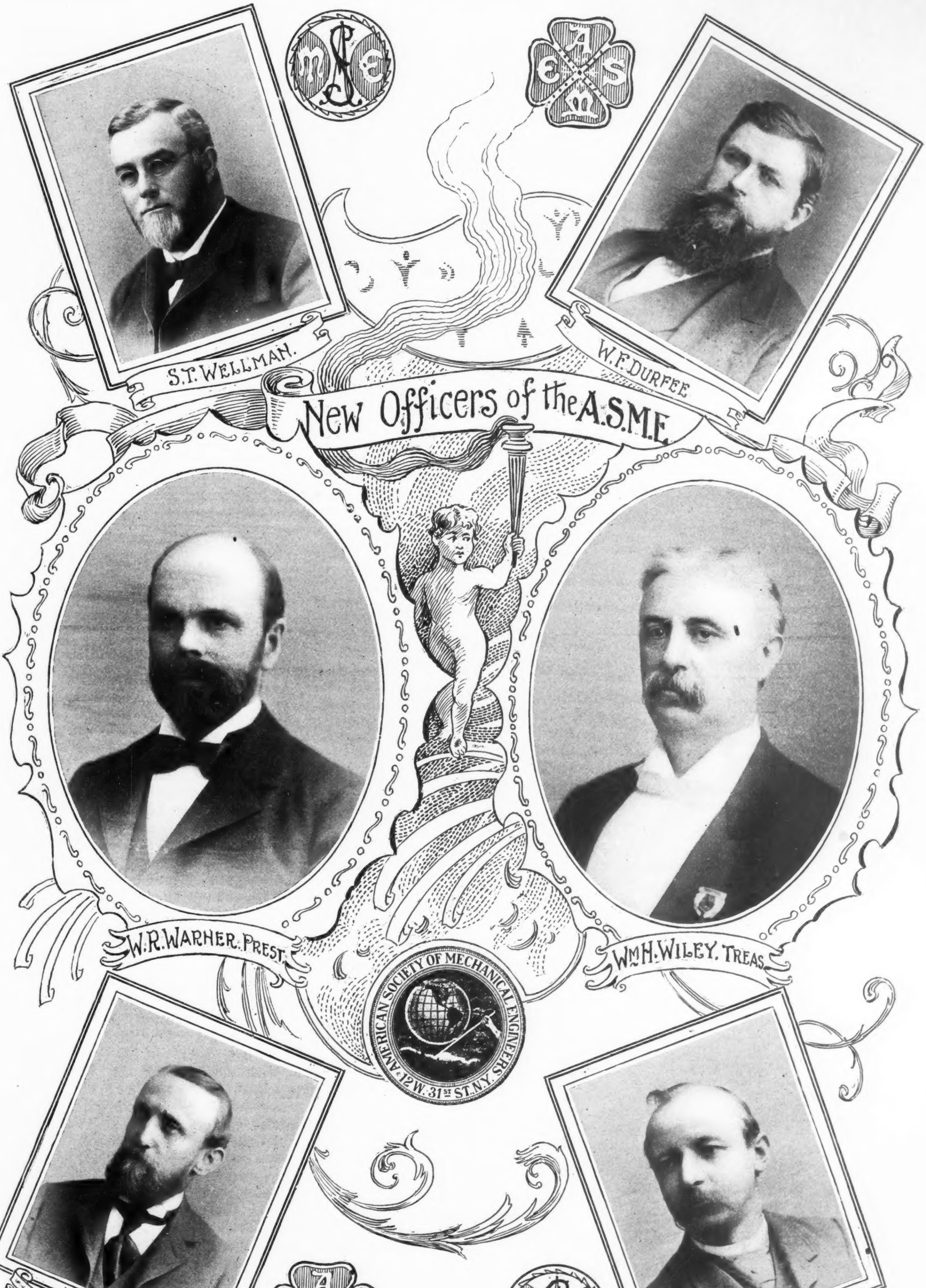
Mr. Wm. H. Wiley is a publisher of technical books, the firm name being John Wiley & Sons, and is one of the best known men in the Society, being the New York correspondent of *Engineering*, of London.

Mr. E. S. Cramp, the superintending engineer of the Cramp Shipbuilding & Engine Co., Philadelphia, Pa., is so frequently quoted as an authority on marine affairs as to need little introduction. His present position is the result of years of experience in this line.

Mr. S. T. Wellman, of the Wellman-Seaver Engineering Co., Cleveland, Ohio, designers of the large Gantry crane illustrated on a previous page, is well known in connection with this branch of engineering.

Mr. W. F. Durfee, of New York City, can be safely called the historian of mechanics at the present time, and when anyone imagines they have a new device it is more than likely that Mr. Durfee can show him its counterpart, made by some other ingenious mechanic, hundreds of years ago, when the mechanical world was in its callow youth.

Mr. Gus. C. Henning, the only manager whose portrait we could secure in time for reproduction, is one of the well known authorities on the chemistry of iron and steel, being one of a committee who have been studiously at work on valuable experiments


New Officers of the A.S.M.E.
S.T. WELLMAN.
W.F. DURFEE.
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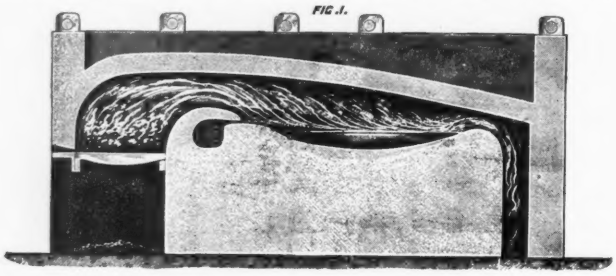
in this line for some time. His long experience as inspector of materials used in structures of various kinds has especially fitted him for his present work as consulting engineer.

THE ORIGIN OF THE BESSEMER PROCESS.

The paper of Sir Henry Bessemer, one of the few honorary members of the Society, gave a very interesting account of this process, which is now used so extensively. Its history really starts from experiments made in January, 1855, to improve the quality of cast iron for heavy ordnance. Avoiding the difficulties or Fairbairn's plan, he employed a reverberatory furnace in which pig iron was fused, forming a bath. Into this he put broken bars of blister steel, its fusion taking place without being further carbonized by contact with solid fuel or contaminated by the absorption of sulphur.

Some of the metal produced was, when annealed, of very fine grain and of great strength, and in the lathe gave shavings like steel. Taking a small gun over to Paris, he was greatly encouraged by the Emperor and given permission to erect a furnace at the government cannon foundry at Ruelle. The Emperor also wished to confer on him the Grand Cross of the Legion of Honor, if permission could be obtained to wear it; this was

FIG. 1.



FIRST FURNACE OF SIR HENRY BESSEMER.

twice refused. The experimental furnace was arranged as shown herewith, the admission of air being shown in both views.

Regarding the Martin-Siemens process, which dates ten years later, he says:

"I desire to say that I make no claim whatever to the prior invention of the Martin-Siemens process, nor do I for one moment assume that my patent of 1855 furnished any information which either of these gentlemen availed themselves of; but I think I am justified in saying that the fusion of steel in a bath of pig iron, on the open hearth of a reverberatory furnace, which I had patented and successfully effected, was, to use a favorite expression of Mr. Gladstone, '*approaching within measurable distance*' of that now well-known and successful process."

FIG. 3.

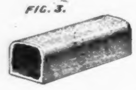
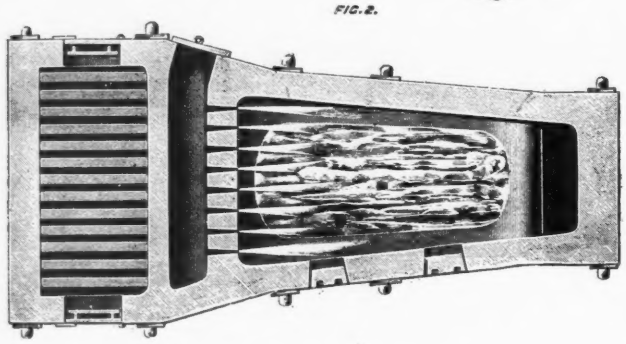


FIG. 2.



TOP VIEW OF FURNACE.

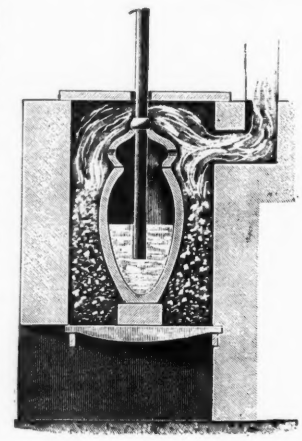
The next paragraph is also interesting:

"On my return from the Ruelle Gun Foundry, I resumed my experiments with the open-hearth furnace, when the remarkable incident I have twice referred to, occurred in this way: Some pieces of pig iron in one side of the bath attracted my attention by remaining unmelted despite the great heat of the furnace, and I turned on a little more air through the fire-bridge, with the intention of increasing the combustion. On again opening the furnace door after an interval of half an hour, these two pieces of pig still remained unfused. I then took an iron bar, with the intention of pushing them into the bath, when I discovered that they were merely thin shells of decarburized iron, as represented at Fig. 3, thus showing that atmospheric air alone was capable of wholly decarburizing gray pig iron and converting it into malleable iron without puddling or any other manipulation. It was this which gave a new direction to my thoughts, and after due consideration I became convinced that if air could be brought in contact with a sufficiently extensive surface of molten crude iron. the latter would rapidly be converted into malleable iron."

This led to the furnace in the next illustration, the air blast being introduced through the pipe shown in the crucible. Thirty minutes' blowing converted ten pounds of gray pig iron soft malleable iron. This showed that molten crude iron could be absolutely carburized without manipulation, but not without fuel, Then followed details of his experiments, which were extremely interesting and which we regret being unable to give in full.

Sir Henry also anticipated Sir Joseph Whitworth, in a patent for casting steel under great pressure. In his patent of May 31, 1856, he says:

"I have observed that the cellular condition of cast steel, and more especially malleable iron castings, is more or less owing to the spontaneous disengagement of gaseous matter in the interior of the fluid mass. Now, it is well known that substances capable of vaporizing, or of evolving gaseous matters, do so with greater difficulty if surrounded by a dense atmosphere. I therefore make use of this peculiar property of matter in order to increase the soundness of ingots or other articles formed by casting in fluid malleable iron or steel."



It is to Whitworth's credit, however, that as soon as he found that he had been anticipated in this, he immediately went to Sir Henry, obtained a license under his patent and paid a royalty on all compressed steel made at his works, until the patent expired. This is noteworthy and highly commendable in view of the wholesale appropriation of patents and designs going on at present. The paper as a whole was extremely interesting, and will be referred to by many who wish to obtain a brief and accurate account of the Bessemer process.

CUTTING BEVEL GEARS WITH ROTARY CUTTERS.*

We quote from the paper of Messrs. F. R. Jones and A. L. Goddard:

The usual methods in shops which do not make a business of cutting bevel gears is either to run several trial cuts and test the gears until they mesh satisfactorily, or to file the teeth. While such "cut and try" methods may produce teeth whose outlines are more nearly the correct form for bevel-gear teeth than those of teeth formed with two cuts, very frequently they do not, and the extra time required for such operations is generally time wasted.

The operations in detail required to cut bevel gears with rotary cutters in a milling or similar machine are as follows: After the gear blank is set so that its axis lies in the median plane of the cutter and at the proper angle of elevation, cuts are run through it to rough out two or more of the spaces between the teeth; the middle of the tooth and its thickness are then marked on the pitch circle of the large end; the gear blank is then revolved through a small angle, less than that of a single pitch, and the table moved sidewise until the side of the cutter passes through one of the pitch points marking one side of the large end of the tooth, and a cut is taken on one side of all the teeth. The blank is then revolved an equal amount on the opposite side of its original position, and the table shifted to correspond, after which a cut is taken on the unfinished sides of the teeth, thus completing the gear.

The only uncertainty in these operations is that of revolving the blank from its original or central position through such an angle that the cutter shall pass through the pitch point of the larger end of a tooth, and at the same time cut just enough off the smaller end to allow the gear to mesh with its mates without further dressing of the teeth.

* Abstract of a thesis presented by Mr. Goddard for the degree of B. S. in Mechanical Engineering.

(CONTINUED ON PAGE 159.)

DESIGNING AN ENGINE SHAFT GOVERNOR.—I.

THEO. F. SCHEFFLER, JR.

Before going into the principal detail work of the shaft governor for this engine (16×24-inch, four valve), it will probably be as well to give a general description of the shaft governor, and the mechanical theory of same, to show how the governor controls the steam valve. In the first place, it will be well to mention the principal elements of a shaft governor. The main part to which all parts are attached, is the pulley, and sometimes only a frame or a skeleton; the two weight arms which are used for the purpose of giving motion directly to the eccentric by means of two connecting links or rods; the two tension, or sometimes compression, springs; the main eccentric, which is connected directly to the weight arms by means of the two connecting-rods and pins, and gives a direct motion to the valve by means of the eccentric and strap, and the dash-pot and connections for same. The forgoing constitute the principal elements of an ordinary and modern shaft governor. In some of the designs of shaft governor there is an inertia weight arm, but in this governor it is not used, and therefore it will not be analyzed.

In any ordinary shaft governor there are two forces. The force tending to radiate from the center of the shaft is called the centrifugal force; the force tending towards the center of shaft is called the centripetal force. The weights are suspended to governor frame in such a manner as to cause them to swing directly from the center of the shaft from their fulcrums; as the governor frame begins to revolve, and when a certain number of revolutions have been attained, the weights begin to move from the center of shaft, due to the centrifugal force. The measure of this centrifugal force depends very much upon the distance in feet from the center of the shaft to the center of the suspended weight, and upon the square of the number of revolutions, and also on the weight itself. For instance, a wheel revolving 200 revolutions per minute; distance from center of shaft to center of weight, 1.5 feet; number of pounds contained in weight, 100; multiply all of the above together*, and then multiply answer by .000341, which gives 2 046 pounds centrifugal force. Now keep the same number of revolutions, the weight the same, but change the distance from the center of the shaft to just double the above distance, making it 3 feet, and multiplying together, our answer is just 4 092 pounds, just double what we had before. Now go back to original figures, but double the number of revolutions, and we have, $1.5 \times 400^2 \times 100 \times .000341 = 8\,184$ pounds centrifugal force, which is just four times our centrifugal force for first example, and twice as much for the second case; doubling the number of revolutions, we have our centrifugal force increased four times, as it increases with the square of the revolutions. Referring back a little, it will be noticed the writer said: "As the governor frame begins to revolve, and when a certain number of revolutions have been attained, the weights begin to move from the center of shaft due to the centrifugal force." If there had not been a retarding force to the weight, it would have commenced to move from center of shaft immediately when the governor frame began to revolve, but the weight has a retarding force and this is the spring which acts as a centripetal force against the weight forces. This centripetal force must very nearly balance the centrifugal force, when the weights are nearest the center of shaft, or their inner position for a certain number of revolutions; there is, however, a greater centripetal force at the maximum inner position of the weight. When the weights are in this position, the valve has its maximum travel; consequently the steam would be cut off at the latest point of stroke, and the engine would be developing its maximum power. At this particular point the centripetal force would be greater than the centrifugal force. If the whole load was now thrown suddenly off the engine, the tendency would be for the pulley to revolve faster; this would cause the weight to increase its distance from the center of the shaft, and would consequently cause a greater centrifugal force in the weight, thereby overcoming the now lesser resistance of the spring, or centripetal force; of course the distance the weight travels from its inner position to its maximum outer position depends greatly upon the motion of the eccentric, which must be moved across the shaft in order to move the valve and cut off the steam. When the weight has moved far enough out from the center of the shaft to cut off the steam, the increase of revolutions should be checked immediately, and the governor should have perfect control of the engine; the tension of the spring should counter-balance the centrifugal force of the weight, thereby being in perfect harmony with each other; though probably the number of revolutions would be increased to two or three more than they were when the engine was loaded; but on the perfect theoretical governor, the number of revolutions should not change to any extent, although in calculating the springs and weights, allowance is generally made for about five revolutions, or about 2 to 2½ per cent. of total number of revolutions.

* Use square of number of revolutions.

Supposing, as the engine is now running light, a load should be suddenly thrown on the engine, the pulley would now act directly opposite to what it did in the first case; the wheel would tend to revolve slower, decreasing the centrifugal force and increasing the centrepetal force, which would consequently let the weight come towards the center of the shaft, and the centripetal force would, so to speak, be pulling in on the centrifugal force; the weight would continue coming in until the governor had control of the load which the engine might have on it, when it would be in perfect harmony once more until another change in load was made. It will now be necessary to explain the initial tension of the springs. The initial tension of the springs is the amount the springs are first opened up to secure the centripetal force that would just balance the centrifugal force for a certain fixed number of revolutions. For instance, supposing the revolutions were fixed at 250 per minute when the engine was loaded, and at this point the centrifugal force of the weight was 1 000 pounds; then the spring would necessarily need to be strong enough to hold this weight under perfect control with perfect safety to the spring, and the tension on the spring should be equivalent to the 1 000 pounds centrifugal force. It would not be necessary to resist more than 1 000 pounds, for if it changed more or less than the 1 000 pounds, the centripetal force would not be in balance and consequently not in harmony with the centrifugal force, and therefore the engine would probably "race" or "hunt," as it is termed, the engine pulley would slow down, and then the weight coming in suddenly, would admit a greater quantity of steam into the cylinder, and then the speed would suddenly increase again, and so it would keep it up, unless the spring was in perfect balance with the weight. It will be observed that the word "equivalent" was used; if the spring was within 4 or 5 inches of the fulcrum of the weight arm, and the weight was about 15 inches from the center of fulcrum of weight-arm, then the tension would have to be about 3 000 pounds at the spring to equal the 1 000 pounds at the weight, providing the spring was at right angles to the weight.

There is probably no place where load handled by engines is as hard on an engine and governor, as the electric motive power service for street railways. Here the load is being continuously thrown on or off very suddenly, and it taxes the governor to its utmost to fulfil its duty, to constantly change the valve for the required load, or no load but the friction of the engine and dynamo, and possibly a car or two. Of course, a good governor can handle a load on the engine in this manner, from no load to full load, with but a small change in the number of revolutions either one way or the other; this, however, is very hard on the springs.

One principal reason why an engine should not change more than 1 or 2 per cent. when connected to a dynamo, is that where there is a very large pulley on the engine and a small one on the dynamo, the ratio of change made on the number of revolutions on the dynamo would be too great, if the engine should change more than 2 per cent., and consequently the current of electricity would decrease to some extent; if on the other hand the engine was used for incandescent electric light dynamo, the lights would not be steady, if the engine did not regulate well. All dynamos are rated for a certain number of revolutions, and to insure that number of revolutions the engine must regulate perfectly.

To continue with governor: as the assumed centrifugal force is 1 000 pounds when the weights are at their inner position on each weight, the centrifugal force will increase to probably 1 400 pounds at their outer position; but as the weight moves out with an increase of force, they meet with an increasing resistance and consequently brought to rest, the pulley will commence to decrease in rotative speed, and the rapid increase of the centripetal force will now balance the centrifugal force caused by the decrease in speed and the weight tending to be pulled back by the tension of the spring. We will therefore require a spring

that will be strong enough to resist the above 1 400 pounds assumed, with perfect safety, that is within the safe limit of spring opening per coil, so that the spring will not take a permanent set. When the two opposing forces, that is, the centrifugal and centripetal forces, balance one another to a certain extent, they will increase and decrease in exact harmony with each other as the weights move out, or in, from the center of the shaft. What is required is good stability, and to secure this the governor weights must be in perfect equilibrium with the springs. Of course, when the weight does move out, and meets more resistance from the spring, and the spring stops the weight for the desired change in load, then they are in a state of equilibrium, for what the spring holds in force, so does the weight equal in force, for if the weight had not the same force as the spring was exerting, then the spring would pull in again, and vice versa. A change of 2 per cent. in the regulation is exceedingly rare, and occurs only in the case of electric motive power as stated, or possibly when the main shaft suddenly breaks, or in the case of a main or leading wire being parted, or a large main belt should break, and were either of the above to take place, the slight increase of the speed of the engine would be of no possible detriment. There must be a change of speed at every change in the load, otherwise no regulation whatever could occur in any governor. When the engine is running loaded, and any ordinary change occurs in the load or steam pressure, the governor is so sensitive and the change in speed is so slight and occurs so quickly that it probably does not exceed ¼ of 1 per cent.

The friction of a governor should depend very much on the design of steam valve that it must control. If the valve is perfectly balanced the same as a piston valve and requires but little force to move it, outside of the little amount of its own friction and in valve-rod stuffing-box, then but a small amount of friction is necessary in the working parts of the governor; in fact no extra amount would be required except what the governor would have under any ordinary circumstances, to obtain a good stable governor. On the other hand, if the valve is not perfectly balanced, and requires from three to four hundred pounds to pull it, in addition to other frictional parts, the governor will require considerable more friction than would otherwise be required to handle the valve. This friction is absolutely necessary on account of the required stability of the governor and to prevent any possibility of racing or hunting. When we add friction to the governor, we also require more centrifugal and centripetal force, and it is necessary with an unbalanced valve to have the centrifugal force at least three times as great as the valve force required, or the number of pounds necessary to pull the valve continuously throughout the stroke. For instance, if a pull of 400 pounds was necessary to control the valve, a centrifugal force of 1 200 pounds would be necessary at each weight at the governor in addition to the amount required for friction of governor parts, in order to control the valve perfectly, and at all points of the stroke. The theoretical mean position is between initial tension and maximum tension of the spring. For instance, if the initial tension of the spring, as in the former case, was 1 000 pounds, and it is necessary to have 1 200 pounds to control the unbalanced valve, we would have a total maximum tension on spring of 2 200 pounds when the weight was at its extreme limit from center of shaft; and consequently the difference would be 1 200 pounds between initial tension and maximum tension. The above 1 000 pounds would cover all friction in the governor.

There is a point on almost every shaft governor, when a partially balanced valve is used, where the valve has control of the governor instead of the governor controlling the valve; this happens when the center of the governor eccentric is not on a dead center line with the center line from where eccentric is suspended, or with center line of engine, and at this particular point the governor is the weakest, and we must arrange sufficient leverage to overcome this difficulty to enable the governor to control the valve at any point of the stroke. It is at the above particular point where we require a sufficient amount of friction in eccentric case attached to governor that will prevent the eccentric turning in its case, due to the thrust of valve working back against the governor. The dash-pot is used for the purpose of giving greater stability to the governor, and to the two opposing forces, thus keeping the two in perfect harmony and equilibrium, which could not very well be accomplished without its use. We will proceed in the next issue with the governor especially designed for this engine.

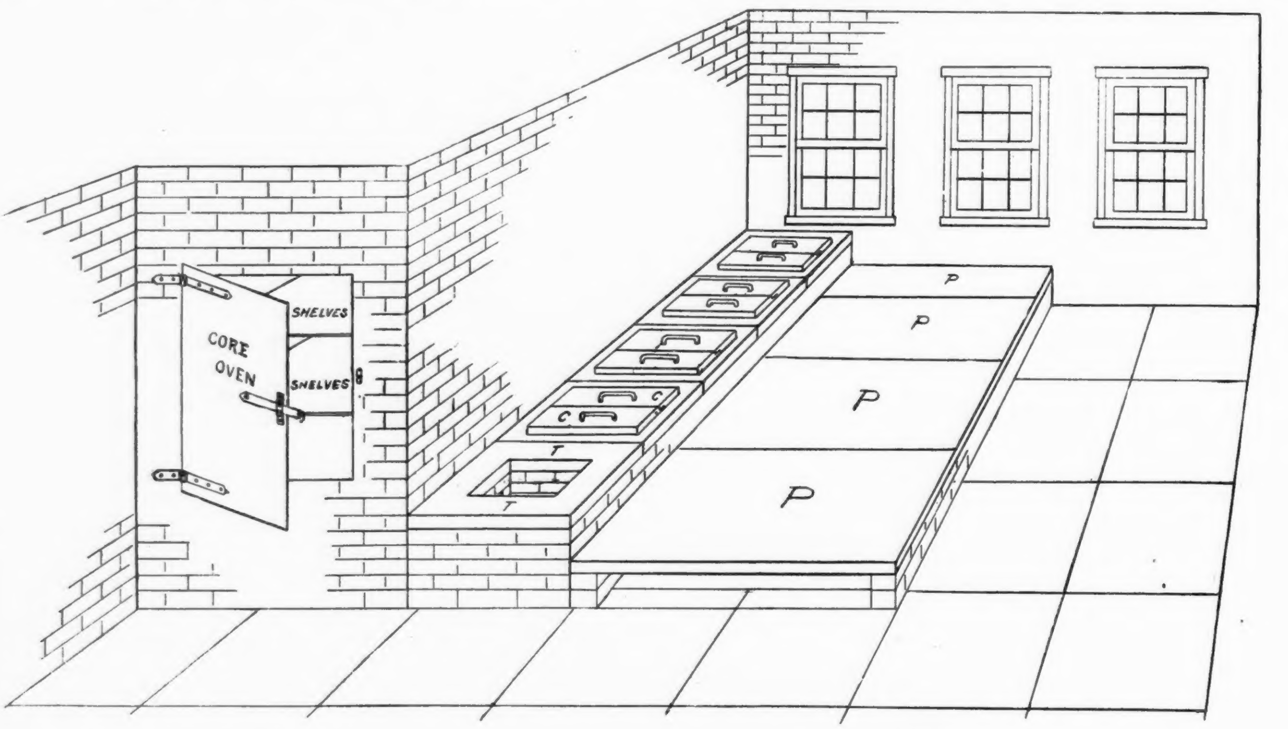


FIG. I.—REGULATION BRASS FURNACE—SQUARE FURNACES.—BRASS FOUNDRIES.

* * *

A GOOD WAY OUT OF IT.

Rather an amusing story of the effect of the newspapers booming business, was told at the last A. S. M. E. convention. One of the Pittsburg rolling-mill superintendents was greeted one morning by a young army of boys, who, in accordance with reports of large orders and returning business, had determined to apply for positions. Telling them there was no place for any of them, he was surprised for several days to receive the same number of applications, but none could be hired.

This became monotonous, and he finally determined that hiring one of the boys would be the best way out of it. The boy was accordingly given a piece of pipe and stationed by one of the gear trains *to blow the dust off the gears.* It didn't take long to use a boy up at this work, and after standing it a few hours he gave up. One more hardy youngster gave it a trial, but succumbed

and there have been no further applicants. The absurdity of the work given them to perform brings a smile, in spite of the regrets that there was not enough legitimate work for the boys.

* * *

BRASS FOUNDRIES.—I.

SOMETHING ABOUT FURNACES.

While there has been very little change in the methods employed in brass foundries for a number of years, there are comparatively few machinists who are at all acquainted with this branch of the trade, and a little information in this line may be of interest and value to some of them.

The core oven is adjoining it and is heated by the escaping gases from the furnaces as will be seen from the section drawing in figure 2. While the sketches are not drawn to scale, they represent the proportions fairly well. The floor plates are perforated to allow any metal or dirt to drop through into ash pit, and in this case the outer ends are supported by pedestals made of about six inches of 2-inch pipe with a flange screwed on each end; these are not shown in sketch. The ash pit is about 3 feet below floor level and probably 4 feet wide, giving room for a boy to work, cleaning the fires and getting out ashes. The original plan included the use of an old chimney as an ash shute, and was gratefully used by the boy in charge of the ash department, until it filled up, never to be opened again, save by the use

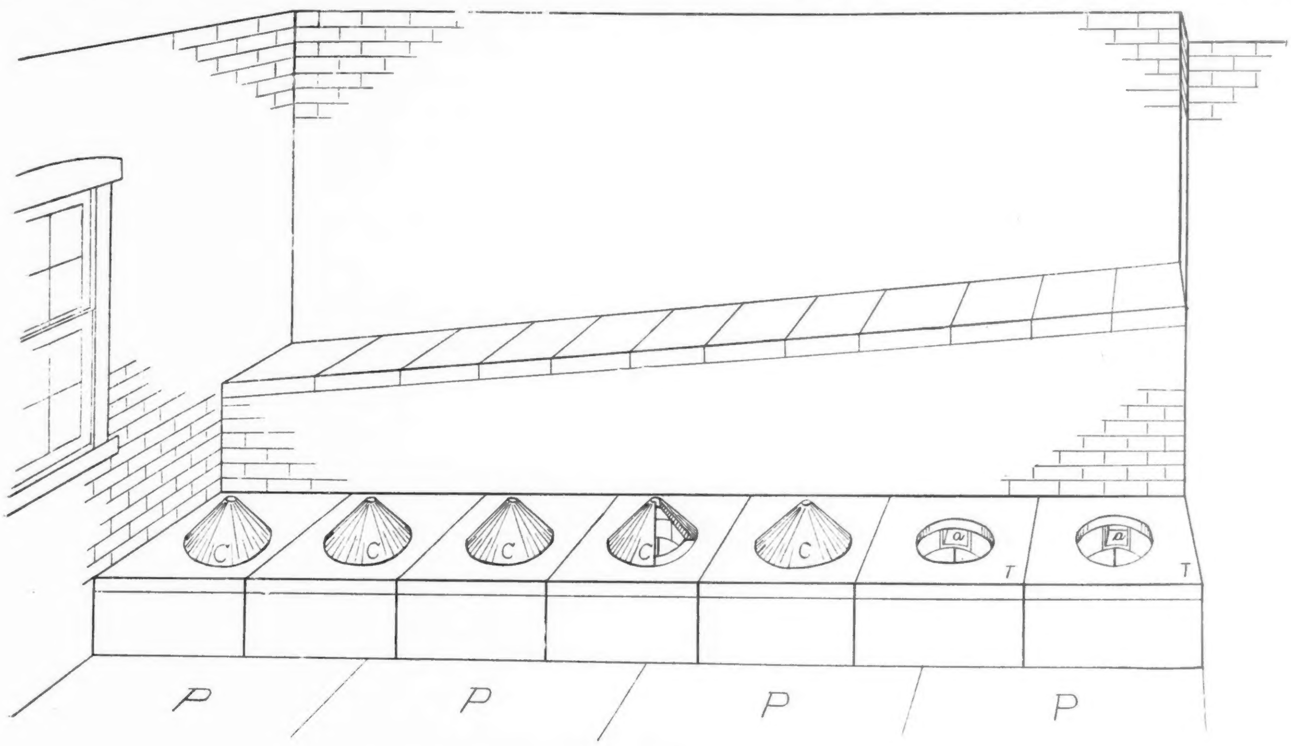


FIG 2.—AN IMPROVEMENT ON FIG. I—ROUND FURNACES.—BRASS FOUNDRIES.

As with iron castings there is green sand and dry sand work, the latter moulds being baked either in ovens, around stoves or by placing heavy hot plates over them. Sections of moulds which are of small size and liable to be washed out of place by the inflowing metal are often baked by placing hot plates or even coals over them, after they have been made ready to clamp for pouring. The moulding, ramming and venting of moulds will not be discussed, as it is similar to any moulding, the variations being due to the difference in metals being handled.

The furnaces in many foundries are crude affairs and can be called without much exaggeration, a bricked up hole, a few old pieces of iron for grate bars and a cover. The question of convenience is too often overlooked and the work of the foundry helper is made much harder than it should be, so there is little wonder that boys are averse to beginning life in a brass foundry.

The question of economy, either of fuel or labor in attending to the fire is rarely considered, and brass furnaces are much the same as they were 20 years ago. Fig. 1 shows a foundry furnace of the usual type, which was built in 1890, and which does not differ materially from furnaces of much earlier date. There are six furnaces in this group or bank, each about 24 inches square, (outside measurement) and consisting of cast iron bodies or plates bolted together. The furnace is square both inside and out, the lining being of ordinary fire brick about 4 inches thick. This leaves an opening of 16 inches for the pot or crucible, which allows about 2 inches on a side around a 175-pound pot

of dynamite or something equally forcible. Then the shute was abandoned and the ashes thrown up to the floor and carted down on the elevator by the still grateful boy—grateful because he didn't have to carry them down stairs. This is one of the joyous phases of the "boy's" life in the brass foundry, as it is usually conducted.

The grates consist of ¾-inch iron bars, pushed through holes in the brick work, with a hook or eye on the outer end, or nothing at all as the case may be. The sketch shows an eye on end for bar, just for appearance sake. The hook or eye help in pulling it out to dump the fire. The coal consumption varies with different conditions, draft, etc., and it seems strange that so few foundries make any provision for forced

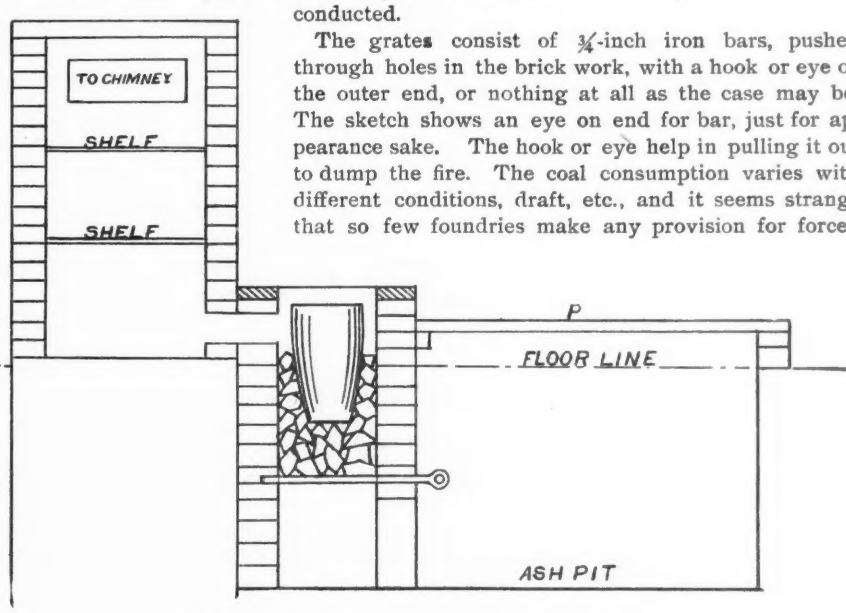


FIG. 3.—SECTION OF FIG. I.—BRASS FOUNDRIES.

draft. Not that it is necessarily more economical at all times, but there are times when the natural draft is below its normal intensity and time as well as fuel, could probably be saved by the use of a blower. There is probably a certain rate of combustion at which each furnace will give best results, and if a

small blower was at hand to be used when needed, it would be possible to maintain the economical rate of combustion at all times.

This subject is very little thought of, probably because the majority of brass foundries are small affairs, not running over three or four furnaces and about the same number of moulders, so that the total fuel cost does not assume very large proportions; still there is room for vast improvement in this department and it should be looked into by the economical manager.

The fuel consumption in the furnace shown was given me as 2 000 pounds for five days, to each three furnaces, or 400 pounds melted with 133 pounds of coal. The cost of coal is so small in pounds per day or 133 + per furnace, per day. These run two heats a day, melting on an average about 160 pounds per heat in each furnace, or 320 pounds of metal. This comparison with the cost of metal melted has been neglected entirely too long. Leaving this back breaking furnace, for the cleaning out of the ashes and the lifting of pots with 160 to 180 pounds of metal out of a hot furnace, by hand (with tongs of course) is hard work, we can consider a marked advance in the foundry of H. Belfield & Co., Philadelphia, Pa., (Fig. 2) which, as well as the whole plant, is in charge of Mr. Alfred Belfield.

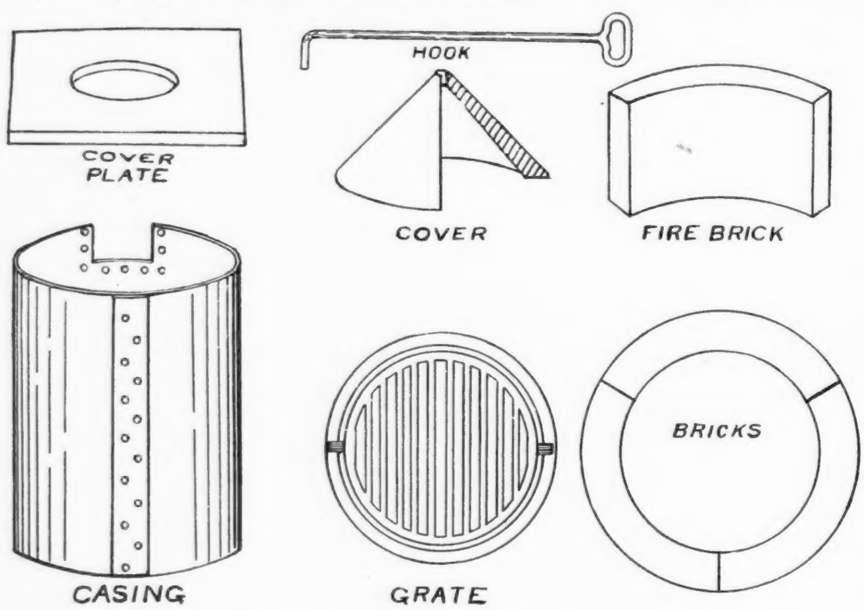


FIG. 4.—DETAILS OF ROUND FURNACE SHOWN IN FIG. 2.—BRASS FOUNDRIES.

This was not completed at the time of my visit, but enough was in place to indicate the improvement which has been made. The whole bank is to include eighteen furnaces, eight of which were already in place. Fig. 3 gives a general idea of the arrangement of these furnaces across the end of the foundry away from the moulders, who can keep comparatively cool; quite a change from the ordinary foundry in which this receives little or no attention. The furnaces connect with the flue behind which gradually increases in capacity toward the chimney to take care of increased volume of gases from the additional furnaces. This flue is closed at the top with large brick slabs which can be readily removed in case it is necessary to clear out the flue for any reason. In fact everything about this foundry has been designed with a view to easy and quick repair when necessary.

The furnaces themselves are seen in figure 4, and consist of iron or steel shells 26 inches in diameter by 30 inches long. These are riveted with a butted seam, as shown and a notch or opening left, to which is bolted a cast iron funnel or nozzle, which leads into the smoke flue, these are lined with fire brick, "three pieces to a circle," as shown in the figure, and as they are three deep, there are but nine bricks to a furnace, making it an easy matter to renew any layer, or the whole furnace if necessary. These bricks are regularly carried in stock by fire brick makers and are not special, as might be supposed.

There is a cast iron base ring which rests on the foundation and on which the dumping grate and its ring are places, the furnace-shell resting on the outer grate ring, the grate is somewhat different from the miscellaneous collection of bars shown in the other furnace, being cast with trunnions for dumping and a catch in front not shown, but this probably cost no more than the bars first shown, and is decidedly more convenient.

The top or cover plate is also shown in the figure, being simply held to the bottom plate by four bolts, then the front bricked in to prevent radiation of heat, both for economy and comfort of man or boy cleaning out the ash pit. The ashes are here shovelled into a metal shute, (not an unused chimney) and there is no difficulty in having them carted away from the ground floor end of the flue.

The cover plates in the first case were rectangular with wrought iron handles cast in them, to be removed by hooks before lifting the pot. Figure 4 shows the round cover used in the latter furnaces and having a round hole in the top, allow the insertion of a hook as shown. These make a very handy furnace in all respects, and one that is economical as well. Other features will be treated later.

It should perhaps have been previously stated that both these foundries are on the top floors of their respective buildings, the former being on the fourth, the latter on the sixth floor. This is such an improvement over the ground floor foundry (when the building is of more than one story) that it is being almost universally adopted. The cost of elevating the fuel, metal, etc., is small as compared with the increased value of the other stories, for the writer knows, from sorrowful and heated recollections the almost unbearableness of the room over a lively brass foundry; the heat and the disagreeable gases make it particularly undesirable, particularly for renting purposes. You may be able to make your own men stand it, (and lose money thereby) but no tenant will occupy it without a concession in the rent bill.

* * *

THE December number of the *Engineering Magazine* contains a valuable article by Mr. Geo. H. Hull, on "The Cost of Iron as related to Industrial Enterprises," which everyone who is interested in the production or sale of this metal should read. The article is a condensed exposition of the value of the "warrant system," which has been in existence in Scotland for over fifty years, and has been beneficial there. Lately this system has been introduced here by the American Pig Iron Storage Warrant Co., and the comparitively limited time that it has been tried in this country has demonstrated that its universal adoption would be of great value to the trade.

* * *

LATHE CONES AND BACK GEARS.—1.

R. E. MARKS.

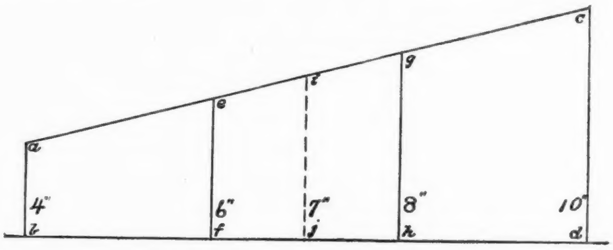
There are many mechanics and draftsmen who are a trifle shady on the question of back gearing and cones for lathes. as well as length of belt and speed of lathe at various steps of cone. There is nothing mysterious about it, as it only requires a little thinking and figuring, which is easy enough after you get on the right track. It is very necessary to have the cones of such size that the belt will run with a practically even tension on all steps of the cone. This was ably treated by W. L. Cheney, in the issue of April, 1895, and the formulas he gave will be used here. First let us assume a few conditions and then work them out as in actual practice.

We want our cone to have four steps, the largest to be 10 inches in diameter, the smallest 4 inches, the diameter being measured at the center of the cone. We know without any figuring, that the nominal diameters of the other steps of the cone would be 6 and 8 inches respectively, a difference of 2 inches between each step, making them 4, 6, 8 and 10 inches respectively If we wish to reason this out, we can say that, starting with our smaller step 4 inches in diameter, we have three other steps, the last of which is 10 inches in diameter. Subtracting 4 from 10 we have 6, and dividing by 3 we get 2 inches as the difference between the steps. Or by graphical methods, which are both attractive and useful, we have it clearly explained as follows:

Draw the vertical lines, *a b*, to represent the 4 inches by any scale (in the cut it is a half inch or one-eighth scale), and *by the same scale* draw *c d* to represent 10 inches, the distance apart is of no importance. The line *a b* represents the center of the smallest cone and *c d* the center of the largest. Connect *a* and *c* as shown. Divide the distance *b d* into three equal parts and erect lines *e f*

and *g h* till they meet *a c*. The length of these lines will represent the centers of the other steps and give their nominal diameter, which is as marked and as found by figures. If it had been a three step cone, the distance *b d* would have been halved and *i j* would have been the nominal diameter, or 7 inches.

Owing to the change in the angle of the belts and the difference in contact with the circumference of the pulley, a belt which was right for the largest and smallest cone (for we have assumed the



cone on the countershaft to be the same as on the lathe) would be too loose for the other steps of the cone, the extra length depending on the diameters and the distance between lathe center and center of countershaft. This we assume to be 8 feet, which gives a good length of belt in practice.

To find the true diameter we use Mr. Cheney's adaptation of Rankin's formula, which is

$$\frac{D+d}{2}+\frac{(D-d)^2}{12\frac{1}{2}C}=$$

true diameter for the middle pulley of the three-step cones in both counter and lathe.

In this formula,

D = diameter of largest cone in inches.

d = " " smallest " " "

C = distance between center of lathe cone and counter cone, in inches.

This is really the nominal diameter plus the "excess" diameter, the latter part of the formula being this excess, which it will be seen depends directly on the distance between centers.

For a four-step cone we add two-thirds of the "excess" diameter to each of the middle cones. For a five-step, add half the excess to the second and fourth grades; for a six-step cone add one-third to each of the four middle grades, which is near enough for all practical purposes.

The true diameter for the middle step of a three-step cone would be

$$\frac{10+4}{2}+\frac{(10-4)^2}{12\frac{1}{2}+96}=\frac{14}{2}+\frac{6^2}{1\,200}=7+\frac{36}{1\,200}=7.03$$

or the excess is .03 of an inch, very little in this case, but let us proceed. Two-thirds of this is .02 to be added to the nominal diameters, making the steps 4, 6.02, 8.02 and 10 inches in diameter. This can be tested by the formula for belt length, and it's a good plan to test results as we go along. The belt formula is

$$2\,C+\frac{11\,D+11d}{7}+\frac{(D-d)^2}{4\,C}=$$

length of belt in inches, the letters representing the same quantities as before.

Finding the length of the belt on the end steps first, we have:

$$2\times96+\frac{11\times10+11\times4}{7}+\frac{(10-4)^2}{4C}=192+22+.093=214.093 \text{ inches.}$$

Applying this formula to the assumed diameters of the middle steps, we get a belt length of 214.073, or only .02 less than before, so we know this belt will run all right on all the cones. In this particular case it would have made little difference as to adding the excess, as a trial of the belt length for the nominal diameters of 6 and 8 inches shows the length to be 214.01 inches, only .063 of an inch difference. This is due to the small diameters and long distance between centers; in the case of feed cones it is of vital importance, as the center distance is very short as compared to diameters, and the efficiency of a machine depends largely on the feed.

Before going on with the lathe speeds and back gearing it may be well to look after the feed cones while these formulas are fresh in our minds. Taking the center distance between cone shafts of the feed as 12 inches and assume that the steps of the driving cone are 2, 3 and 4 inches, and the largest driven cone, which is driven by the smallest cone of the driver, to be 7 inches. As these are not "even" cones (not both the same size), we first find the length of belt necessary for the 2 and 7 inch steps.

Using the same formula as before, we have—

$$2\times12\times\frac{11\times7+11\times2}{7}+\frac{(7-2)^2}{4\times12}=38.66 \text{ inches.}$$

The nominal diameters of the other steps of the large cone would be 6 and 5 inches respectively, for as $2+7=9$ so $3+6$ and $4+5$ also equal 9, making their circumference equal to a 9 inch pulley, but the belt length depends on the angles formed by the different steps. Taking the other end of the cone to find what the belt length will be, if we use the nominal diameters of 4 and 5 inches, we have

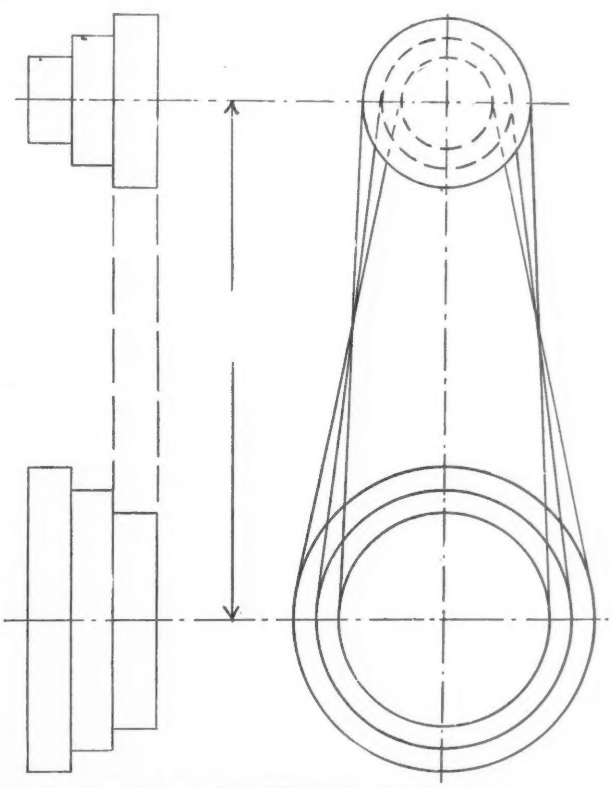
$$2\times12+\frac{11\times5+11\times4}{7}+\frac{(5-4)^2}{48}=38.10 \text{ inches,}$$

or half an inch shorter than on the other end of the cone. We can find the diameter, which will give this difference to either the driver or driven, and practically we can call the addition, two-thirds of this difference, or .36 of an inch, making the driver 4.36 inches in diameter. If we add the difference to *both* cones, we add one-third to each.

Trying center cones we have

$$2\times12+\frac{11\times3+11\times6}{7}+\frac{(6-3)^2}{48}=38.32$$

or .34 of an inch short. So we add .23 to the diameter, making the steps of the driving cone 2, 3.23 and 4.36 inches, and the cone on feed rod 7, 6 and 5 inches. This gives a ratio of 1 to 3.5, 1 to 1.85 and 1 to 1.12 between the feed cone and the cone on



the stud. In other words, while the feed rod is making 100 revolutions, the driving cone must make either 112, 185 or 350 revolutions, according to the position of feed belt, the former for the largest step of driving cone, the latter for the smallest step of driving cone. The question of gear ratios can perhaps best be left for another time.

* * *

One great trouble with tests is that we are nearly always looking for certain results and can very rarely be entirely impartial in our experiments. Mr. Edward J. Willis, a most careful investigator, recently remarked: "If we ask Nature a question, she answers it impartially, while we are always looking for results, which impairs the value of the tests even though we endeavor to be perfectly fair in the matter." This is too apt to be the case; but is a difficult failing to overcome, as were we not interested in the results we would not in many cases make the tests at all, for they are generally made to support preconceived ideas. If it were possible to secure careful investigators without theories as to the result of the test, this might be overcome, but these would probably be as difficult as to secure jurors without ideas of the case in question.

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JANUARY, 1897.

CONTENTS:

A Railroad Testing Laboratory, Wm. O. Webber 135
The American Society of Mechanical Engineers 136
Manufacture of Iron and Steel.. 136
Friction HP. in Factories...... 138
A 200-Foot Gantry Crane 139
Paper Friction Wheels. 139
Ancient Pompeiian Boilers..... 140
The New Officers.............. 141
Origin of the Bessemer Process 142
Cutting Bevel Gears 142
Designing an Engine Shaft Governor.....Theo. F. Scheffler, Jr. 143
Brass Foundries (1)............. 145
Lathe Cones and Back Gears (1), R. E. Marks 146
One Form of Bribery, The Question of Saving, } Editorial 148
How and What to Study, Prof. C. H. Benjamin 149
Valve Gears (3).......E. T. Adams 150
A Mid-Winter Sermon............ 152
Machining Cycle Forgings (1) Onondaga 152
From Actual Practice—A Cranky Notion ...."Milo" 153
Systematic Boiler Designing (1), H. M. Norris 154
Everyday Shop Subjects (3)..Chips 154
Mathematics and Machinists, Arthur B. Babbitt 156
Notes from a Roving Contributor... 157
Machine Design (2).........Junior 158
A Large Engine Lathe............ 158
Items of Mechanical Interest...... 161
How and Why.................... 162
What Mechanics Think........... 163
Manufacturers' Notes............. 164

ONE FORM OF BRIBERY.

Those who are fortunate enough to have money to invest in stocks of new companies are often drawn into concerns which apparently have some devices or patents that cannot fail to be worth millions, according to the promoter; but which ultimately prove of no value, and the investor is fortunate if his stock is non-assessable. We are sometimes consulted regarding the advisability of investing in new mechanical devices or machines, and while there is no cast iron rule which will apply in all cases, there are one or two conditions which usually influence our advice.

It is often impossible to obtain information regarding the invention except what is given out by interested parties, and an outsider has little basis for critical opinion, save in a general way. In such cases it is a pretty safe plan to find out who the engineering expert is and what he claims; then the men who are behind the company, and whether they have stock to sell or not. If, as is often the case, you find the directors are men who could easily raise the total amount for the stock themselves, it is safe to assume that it is not so valuable as the glowing reports would have us believe, for when men who have money to invest find an invention which will save even 25 cent. over existing methods, they do not usually spend time and money to induce the public at large to share the profits with them.

There are cases where it is legitimate and necessary to sell stock in order to raise money enough to do business, but this is when the inventors or promoters have not enough themselves; when they are known to have much more than the total amount required, suspicion of the device follows as a natural sequence.

When you begin to read that "Our steam is hotter, stronger, dryer and better on general principles" than the other fellow's steam, or equally ridiculous claims, it is time to watch the expert and to see how much of the stock has been given for the use of influential names on the board of directors.

This form of bribe-taking has everything to condemn it. Allowing one's name to be used to influence others in consideration of a few shares of stock, when little or nothing is known of the merits of the device, is a worse action than that of the trained elephant who enters the forest to lure others of his kind into captivity, for the elephant isn't supposed to know any better, while the man—well, he ought to, at any rate.

* * *

THE QUESTION OF SAVING.

The questions of efficiency and economy are all absorbing ones at present, and claims are often made with such recklessness that it is well to be a trifle cautious in accepting all of them as absolutely correct. Take for example the steam boiler, and we find guarantees to save from 5 to 40 per cent. in fuel by using a certain boiler, a peculiar setting, or perhaps some smoke-burning or feed-water heating device. These claims are generally made in a circular which gives the impression that they can save the amount named, from 20 to 25 per cent., in almost every case.

A certain boiler setting is advertised as saving 20 per cent. in fuel. This may mean several things. It may mean that any boiler with this setting will save 20 per cent. of the fuel used with the old setting, which is to be doubted in cases where the boilers were well set originally, but which will probably be found true in many cases where the original setting was poor or has been neglected. On the other hand it may mean that the boiler setting, with the boiler supplied by the company, will save the amount guaranteed. This again depends on the standard of comparison, and it is a rash guarantee, to say the least, to send broadcast without regard to the conditions involved.

This habit of comparing a new device with a poor one already known, instead of with the best, or at least average practice in this particular line, can hardly be condemned too strongly. It is too common to find a new type of compound engine, for example, compared with some dilapidated freak instead of with the latest development in this line; and it is no recommendation for a special make of compound engine to say that it is more economical than a simple engine; it should be compared with the best engine of its class in existence.

The example of the Jones & Lamson Co., makers of the well known flat turret lathe, and a few other firms, can be followed to good advantage by those who now indulge in indiscriminate guarantees. Instead of saying they can save a manufacturer 99 per cent. on his cost of production, they prefer to have their representative call and examine the work to be done and the existing methods. He is then in position to give an intelligent estimate as to the cost of work by his machine and need not make any wild guarantee. This is the only rational way to guarantee any saving, as the amount saved depends on the existing conditions; wasteful methods affording a better opportunity for improved devices than methods almost as good as the new one offered.

This is particularly applicable to boilers and other steam

appliances, and if guarantees were always tempered with good judgment, there would be fewer law-suits, fewer dissatisfied purchasers and a better condition of affairs generally. It is too often the case, as the writer once heard agent remarked, that "guarantees are made on the assumption that only one purchaser in ten will ever make a test," which explains how some of the wild guarantees can be made, if not fulfilled.

* * *

HOW AND WHAT TO STUDY.

PROF. CHAS. H. BENJAMIN.

I have been asked to write something concerning the studies a young mechanic may pursue while he is at work at his trade. As soon as I attempt to write about this I see in memory a young fellow of eighteen or thereabouts, bending over a drawing-board, copying by the dim light of a kerosene lamp, odd, Englishy-looking lathes and engines from Cassell's Mechanical Drawing, his pencil point breaking now and then and his line pen spluttering from the heavy pressure of fingers better used to hammer and cold-chisel. He did go to sleep over the drawing occasionally, but he would awake again and struggle on until the plate was finished, and in time he learned to draw after a fashion.

He studied mathematics in much the same way, and ever since that time he has appreciated the difficulties and discouragements of evening work coming after a day of toil. To-day the opportunities for self-improvement and self-instruction are much better than they were then, as a glance at the columns of this paper will show.

In the first place it *does pay* to study if you study in the right direction.

A true understanding of the principles of mechanics and machine design will make you more independent and worth more to your employers in dollars and cents, a fact they will not be slow to recognize.

If you are an apprentice or a young journeyman and want to study, try and find some mate of yours who feels the same, and arrange to study together. You will help to keep each other awake in the long winter evenings, and one light will do for both. Understand at the outset that you cannot learn much about mechanics without studying mathematics at the same time.

If you can attend some evening school in mathematics one or two evenings a week, so much the better; it will be a break in the monotony of your evening work. You must make up your mind to devote at least four evenings a week to study, if you would accomplish much. Even five evenings of two hours each are not too much for a young man in vigorous health.

Life is short, and what you mean to do must be done while you are young. Now this study which we are to talk about is not amusement; it is hard work, and all the harder because you are tired physically and feel more like smoking and reading the evening paper. It will take plenty of pluck and endurance to get learning in this way, and if your are not plucky, but rather lazy and indifferent, just let it alone and stick to your dollar and a half a day, which in such a case is rather more than you are probably worth.

Some will advise you to study algebra and geometry before you attempt anything in the way of mechanics. If you do this, I am afraid you will be discouraged before you get to mechanics, because you will not see the use of it all.

An old friend of mine, a good mechanical engineer, entirely self-educated, once told me that he proceeded in this way: He got some book bearing on his particular work, and began to study it. He soon came to some mathematical formula that he could not understand. He then bought an algebra, studied that far enough to supply his need and began again on his first work. Perhaps a geometrical demonstration puzzled him; he bought a geometry and studied that. So on, until when I knew him he was well versed in all the higher mathematics as well as in mechanics. This may seem like trying to put the cart before the horse, but the method has this one great advantage, that the learner knows at all times what he is after; he does not study algebra until he knows why he needs algebra and the $x^2 + y^2$ has some meaning to him.

We will assume that you have a good common-school knowledge of arithmetic; if you have not, you may study shop arithmetic from the last volume of this paper. First get a copy of some some good work on elementary mechanism, such as Stahl and Wood's, and begin to read it. Do not be alarmed at a Greek letter now and then, as they are perfectly harmless and you may call them anything you please. Get a copy of Wentworth's School Algebra and also copies of Plane Geometry and Plane Trigonometry, by the same author. There may be other text books just as good, but I can recommend these from experience.

Learn from the algebra at first the use of simple equations and how to add, subtract, multiply and divide with letters instead of figures. Do not try to work all the examples, but just a few under each head.

In geometry study Book I. on lines, angles and triangles. In trigonometry try to learn what is meant by sine, cosine and tangent, and study the right triangle, working a few examples; eighteen or twenty pages of the text book will be all you will need at first. All this time I would be reading the mechanism regularly. When you come to something that you do not understand, mark it and pass on, and you will gradually begin to realize what you want of mathematics.

We will suppose that you are reading mechanism two evenings a week, and studying mathematics the remainder of the time. As soon as you learn what an equation is in algebra, look up the equations in the mechanism and see how many of them you can understand and solve. If in the mechanism you find the expressions "sine" and "tangent," refer to your trigonometry and find what they mean. If you learn about similar triangles in geometry, try and find such problems in mechanism, and see how the principles are used. In short, refer from mathematics to mechanics and back to mathematics again, making one illustrate and help explain the other, and remembering all the while that the mechanics is what you are after, and that mathematics is to be used only as far as it helps you.

Look about you in the shop and see what you can find of levers and cranks, gears and cams, to illustrate the principles laid down in the book. If you see a movement that interests you, try and find it in the text book, or at least something like it. At first you may find it dull work, but as you begin to get a glimmering of what it is all about, you will get new courage and interest, and after that the road will grow easier every day. When you have mastered the mechanism and the mathematics which that implies, you will have made a good start on the high road to a mechanical education.

Now if you will buy a little book entitled "Lessons on Applied Mechanics," by Cotterill and Slade, and work through it carefully, doing all the examples that you can and brushing up your mathematics as you go along, you will have acquired a fair elementary knowlege of the principles of mechanics which will enable you to solve nearly all practical problems that present themselves. I have so far said nothing about drawing, for I do not think it of much use to learn that until you know what you want of it. All this time that you have been studying mechanism you should have had a sketch book or pad of note-paper, and made free hand skethes of mechanical movements which interested you and of various machine details. You should accustom yourself to use drawing as a means of expressing ideas, just as you use written words, so that it becomes a second nature to you to sketch anything you wish to remember or describe. If you work from blue prints in the shop, or if you can borrow some to study, this will help you to understand how a drawing is made. You can get some drawing instruments at any time and begin to practice on drawing straight lines and circles, so as to become familiar with the instruments. Anthony's text books on elementary drawing and on machine drawing, are excellent works for the beginner. And here it will be of great benefit to you if you can attend an evening drawing school for one night in the week at least.

When you have become sufficiently familiar with the principles of drawing, the book on mechanism will tell you how to draw gear teeth and cams, and how to design various link motions. Make up your own problems from what you see in the shop, and simply add a little common sense to what you learn from your book in working them out. Brown & Sharpe's Practical Treatise on Gearing is a good book for the machinist and pattern-maker to have. Try and make your drawing, however, a means to an end and not the principal thing. Let me repeat, it is of little use to be able to make a nice drawing unless you know what to draw and why.

The motive for this study may be summed up as follows: You

see many things in machinery which you do not understand. You wish to understand them. Mechanism and applied mechanics tell the reasons of these things. Mathematics is simply a convenient tool with which to work the problems. Drawing is another convenient tool as an aid in expressing to others the ideas which you wish to convey.

But in all cases the problems and the ideas come from your every-day work and that which is around you, and your success will depend upon the close connection which you keep at all times between your acquired knowledge and your practical work.

* * *

VALVE GEARS.—3.

E. T. ADAMS.

The first steps in drawing this card are identical with those taken in drawing the rectangular card (Fig. 3, paper No. 1). We will assume 4 inches as the length of the card and a 40 spring; that is, $\frac{1}{40}$ inch will represent 1 pound pressure. Referring to Fig. 15, draw *o x* 5 or 6 inches long. Draw the atmospheric line A B of the same length, 14.7 lbs. to scale above *o x*. (This will be nearly $\frac{15}{40}$ inch above *o x*.) Lay off the points A and B 4 inches apart, and draw through each a line perpendicular to *o x*. This is the length of the card, and is proportional to the volume of the cylinder; hence, taking 10 per cent. of this length, or $\frac{4}{10}$ inch, to represent the volume of the clearance space, and laying off this distance to the left of A, we locate *o y* the clearance line; $\frac{80}{40}$ inch, or 2 inches above A B, locate the line of boiler pressure, J K. If we allow 5 lbs. drop for the steam-chest pressure we can draw D E, the steam line 75 lbs. above atmospheric pressure, or nearly 90 lbs. absolute pressure; that is, pressure above *o x*, the line of zero pressure. If we assume that the back pressure is $1\frac{3}{10}$ lbs., we can draw the back-pressure line H G $1\frac{3}{10}$ lbs. by scale, above A B, or to make it even numbers, this is $\frac{16}{40}$ inch above *o x*.

Now cut-off, we have assumed, will occur at half stroke; that is, the volume of steam admitted will be one-half cylinder full. This will bring cut-off at E, half-way between the ends of the card at A and B. No more steam is admitted, but the steam already in the cylinder expands to fill the increased volume opened

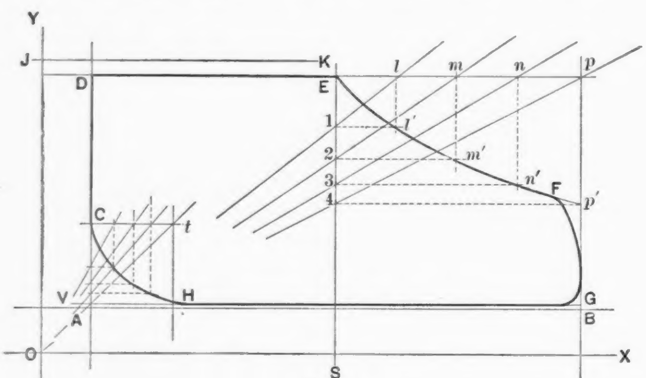


Fig. 15

up by this motion of the piston. This increase in the volume of the steam is accompanied by a fall in pressure and temperature, and this fall is shown by the expansion curve E F. It may be well to say right here that this curve does not show exactly either the theoretical or the actual change in steam pressure with the change in its volume, but the curve shown, which is a rectangular hyperbola, is the curve commonly used and is sufficiently near to the curve obtained either by theory or in practice. The reader will do well to turn back to the June number of this paper, No. 10, Vol, II, and read the instructive article by "M. E." on "The Hyperbolic Curve—Various Methods of Constructing It." It will be well to practice as well as read. Do not attempt simply to follow his diagrams. This course will enable you to *understand* the methods given, but not to *remember* them. "*We learn by doing*," and those who wish to master this thing must take pencil, paper and triangles, and, following the text, actually, draw the lines in the order set forth by the writer. The figures will be a guide when you get into trouble.

The method now given is, I believe, the one most generally used in this country: Through E, the point of cut-off, draw E S perpendicular to *o x*. From *o* draw a series of radial lines, as shown, cutting E S in 1, 2, 3 and 4 and D E produced in *b*, *m*, *n* and p. From 1 draw a line parallel to *o x*, and from the corresponding point *l* in D E p drop a perpendicular. The point of intersection of these lines gives *l'*, one of the points through which the curve must pass. Proceeding similarly with the other radial lines, the points *m'*, *n'* and *p'* are obtained, through which the curve may be drawn. It is to be noted that any number of radial lines may be drawn from *o* and at any distance apart; also they need not be so drawn as to give regularly spaced ordinates as in the figure.

To sum up, we have, so far, the point of admission, on the line C D and of cut-off E, through which we have just completed the expansion curve E *p'*. There remains to be located the points of release F, and of compression H. In the rectangular card (Fig. 3, first paper) release took place just at the end of the stroke, but that was hardly a practical form of valve for an engine, and the speed was very low. It would be found that at higher speeds this would not allow sufficient time for the exhaust steam to escape at the end of the stroke, and we would have a back pressure line G H, very high at the beginning of the return stroke and gradually falling as the piston advanced and the area of the exhaust opening was increased. In Fig. 14 when release occurs *before* the end of the stroke we note a little of this effect. We could avoid even this much by giving a greater opening to the exhaust. This in turn would involve either a larger valve or else an earlier release; that is, an earlier opening to the exhaust passage. The form of card shown, however, is in this respect about as good as can be obtained. Measuring the card shown in Fig. 14, we find the point of release F at approximately $\frac{95}{100}$ of the

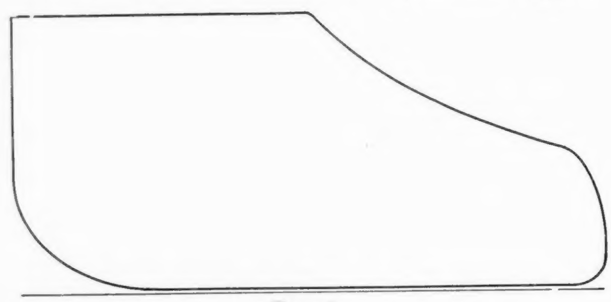


Fig. 16

stroke, and locating this point F on the expansion curve, Fig. 15, we draw in the end of the card, freehand, to correspond with what we find is actually secured under similar circumstances, as shown in Fig. 14, last paper.

Now the point H, where compression begins, is, in Fig. 14, at about $\frac{5}{6}$ of the stroke, and we may draw the compression curve H C, which is also a rectangular hyperbola, as follows: Through H (Fig. 15) draw H *t* perpendicular to *o x*. Through the origin *o* and the intersection *v* of the back-pressure line A B and the admission line D C draw the radial line *o v t*, cutting H *t* at *t*. Through *t* draw a line parallel to *o x*, cutting D *c* at *c*. This locates *c*, the end of the compression curve. The hight of *c* above A B gives the number of pounds, gauge pressure, to which steam will be compressed. Drawing other radial lines, cutting D C, and completing the parallelograms as when drawing the expansion curve, we locate a number of points through which the curve C H may now be drawn. It is to be noted that had C been given instead of H, we could have completed the curve by first drawing a line, *c t*, through C and parallel to *o x*, and then drawing the radial line *o v t*, cutting *c t* at *t*, from which point a perpendicular to *o x* would locate H, after which the curve could be completed as above.

Fig. 16 gives the card completed. The careful reader will note that this card differs somewhat from the card shown in Fig. 14. The older heads among our readers are aware that, when dealing with a plain slide-valve engine, it is easier to assume, as we have, the card wanted than it is to secure in practice the card assumed. Now we have assumed all the points in the theoretical card without any thought as to the limitations of a single valve, and when in the next paper we come to design a valve to produce this assumed card it is quite possible that we may find that there is trouble in store for us.

Fig. 14 gives the card selected as a type, and Fig. 16 gives the theoretical card that we secured with 10 per cent. clearance and other conditions as assumed.

Now we find that at the end of the stroke, Fig. 16, the imprisoned exhaust is compressed to about 30 pounds pressure, which is evidently considerable less than the pressure attained from the same point of compression in Fig. 14. This at once

suggests that there must be some different condition in the two cases, and actually the difference is this, we have assumed that the volume of the clearance space is 10 per cent. of the volume of the cylinder, while the volume of the cylinder in the Corliss engine was much less, probably not far from 5 per cent., or possibly less, of the cylinder volume. We have taken $\frac{1}{8} + \frac{1}{10}$ of the cylinder fall of steam and compressed it into $\frac{1}{10}$ of the cylinder volume. In the Corliss engine $\frac{1}{8} + \frac{1}{20}$ of a cylinder full of steam is compressed into $\frac{1}{20}$ of the cylinder volume, which evidently gives a

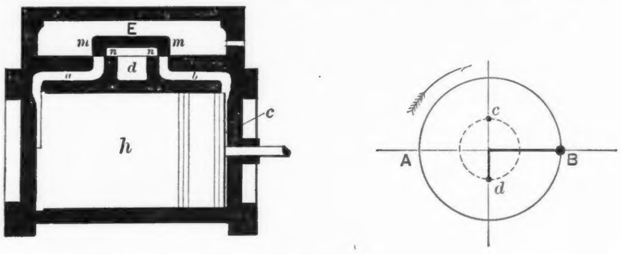


FIG. 17.

higher pressure at the end of compression. Now the question arises, which point shall we take; shall we start from H at $\frac{5}{8}$ of the return stroke, or shall we begin with C at about 65 pounds gauge, as in Fig. 14, and drawing the compression curve through C, locate H at the intersection of this curve with the back-pressure line, thus bringing the point of compression H much earlier in the stroke. This is a broad question, the answer involving a full statement of why we need to compress part of the exhaust at the end of each stroke. The answer is that this is done primarially for a practical reason already hinted at; economy in the use of steam is also a consideration. For present purposes we may neglect the latter, as no one secures and no one expects fine points in economy from a simple slide valve engine. It is clearly understood to be an engine, cheap in first cost, and not at all economical in steam consumption, but anyone can secure, and everyone expects to secure, smooth, quiet running and this is the only part of the question that we need consider here.

We can then re-state the question as follows: With 10 per cent. clearance, will it be better to begin at $\frac{5}{8}$ stroke and compress up to about 30 pounds, or shall we begin earlier and compress higher to 65 or even to 70 or 75 pounds gauge pressure. We may reason it out in this way: at each end of the stroke the direction of motion of all the reciprocating parts is changed, reversing the direction of the pressure on all the pins and bearings. If this reversal from full pressure in one direction to full pressure in the opposite direction, is allowed to take place suddenly, a "thump" or "pounding" is bound to occur, and the engine could not be used either for high-speed or for continuous service. We may

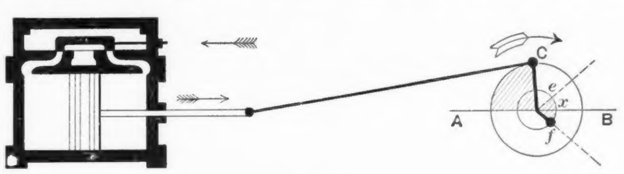


FIG. 18.

avoid this "thump" by avoiding the sudden reversal of pressure, and for this latter purpose steam is imprisoned by the valve and is compressed by the piston as it approaches the end of its stroke, thus bringing the reciprocating parts to rest easily at each end of the stroke and gradually reversing the direction of the pressure on the pins. The reciprocating parts, even of a comparatively small engine, will weigh several hundred pounds, and even at ordinary speeds will move with considerable velocity. We have, then, a considerable mass moving at a high velocity which must be brought to rest with as little jar as possible twice during each revolution of the engine. We should begin to compress early enough in the stroke to insure that this will be accomplished easily, and we should compress high enough to make certain that the direction of pressure on the pins is reversed before the piston reaches the end of the stroke.

However, if we begin compression too early in the stroke it will not only greatly reduce the area of the card and the power of the engine, but at the end of compression the pressure in the cylinder may exceed the pressure in the steam chest by enough to lift the valve from its seat at each end of the stroke. This is a common difficulty with some forms of valve and valve-gear. Amid these conflicting conditions the designer, with experience as his guide, must choose such a point of compression as seems best suited to the type of engine and the service in which it will be used.

A general rule cannot be given, but we may say that at all ordinary speeds, and with the rather large clearance volumes common with engines of this type, compression up to about ¾ boiler pressure will usually give a good result. In the present case we conclude, then, that it would be better to begin to compress somewhat earlier in the stroke. We will not, however, attempt at this time, to locate this point exactly, as it will develop later that the points of release and compression being regulated by the same edge of the valve, can not be chosen at random, and having selected two points in the stroke which seem to us as desirable for these events, we must accept in the end such an approach to them as the limitations of a plain slide valve will admit.

Remembering that admission and cut-off are regulated by, in this case, the outside edges of valve, while release and compression are governed by inside edges we may do well to sub-

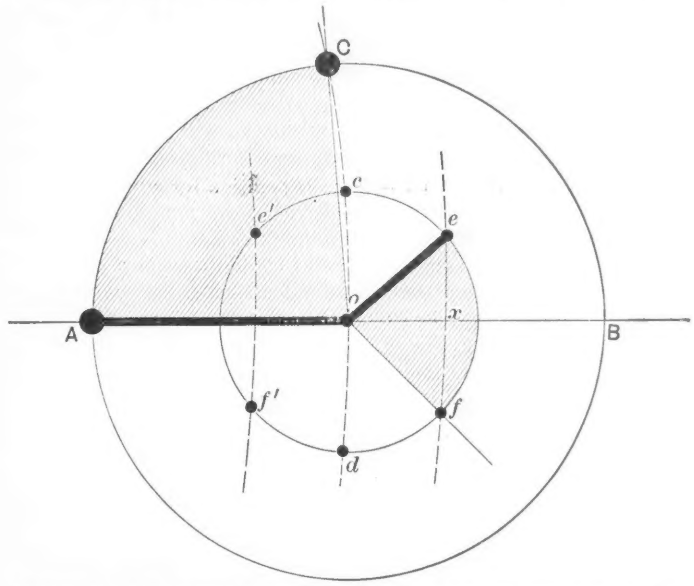


FIG. 19.—ENLARGED DRAWING OF CRANK AND ECCENTRIC POSITIONS SHOWN IN FIG. 18.

divide the problem in hand, taking up first the problems relating to admission and cut-off, and later those relating to exhaust and compression.

The first problem, then, is to determine what changes are necessary in the valve gear already designed for cut-off at full stroke, to make cut-off occur at half stroke.

Fig. 17 shows the valve already designed and gives the relative positions of valve, piston, crank and eccentric, just at the end of the forward stroke. At the beginning and end of each stroke, that is, when the piston is at the piston position for admission and again when it reaches the piston position for cut-off, the valve

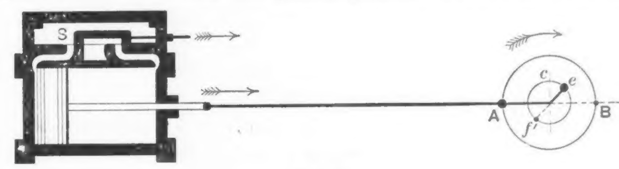


FIG. 20.

must be at the position it now occupies, accordingly at both admission and cut-off the center of the eccentric must lie somewhere on the arc that will be described by the center of the eccentric, if we clamp the valve in its present position and swing the eccentric across the shaft, using the eccentric rod as a radius. This, as we saw in a previous paper (II), locates cut-off at *d*, just a half-circumference or 180° from the admission position at *c*. This was, of course, correct for cut-off at the end of the stroke, since the crank turns through just 180° while the piston makes one full stroke, But we now desire cut-off when the piston is at half-stroke, and reference to Fig. 18 shows that the crank at cut-off will have traveled through the shaded part of the diagram, from A to C or through approximately 90°. Since the valve is to be open for each stroke only while the shaft turns through 90°, we must find a position for the center of the eccentric which will open and close the valve while the shaft, and with it the center of the eccentric, turns through the same angle, that is, through 90°. Now a second condition to be kept in mind is that the valve

must be in the same place for both admission and cut-off, and we must find a position for the center of the eccentric, so that starting with the valve in its position for admission, just 90° will be turned through by the crank and eccentric by the time that the valve is back to the point from which it started, or by the time cut-off occurs. Accordingly, holding the valve fixed and swinging the eccentric across the shaft we find, by trial, that the center of the eccentric must lie either on the arc *e f*, Fig 18 and 19, or on the arc *e' f'*, any other position evidently giving an angle of travel either greater or less than 90°. This necessarily locates the center of the eccentric at *e* when the crank is at A to insure motion in the direction shown by the arrows, and when the eccentric is keyed in position, its center will turn through the arc *e x f* while the crank turns from A to C, each arc corresponding to an angle at the center of about 90°. The shaded portions of the drawing show the angles turned through by both the crank and the center of the eccentric.

We find, then, that the eccentric must be turned on the shaft and its center advanced from *c*; its position where cut-off occurs at the end of the stroke, to *e* where cut-off is to occur at half stroke. With the crank at A the eccentric will now be at *e*, and if all the connections remain unchanged, the valve will be drawn toward the right, a distance almost exactly equal to *o x*, the distance by which we advanced the eccentric on the shaft.

The piston is now at the end of the stroke, the crank on its dead center A, and the eccentric is at *e* the position for admission, but the valve is drawn toward the right until the port is wide open, while the valve should be just beginning to open the port to admit steam for the forward stroke, all of which is shown in Fig. 20.

Now, we remember that the connections from eccentric to valve are of the proper length as they stand.

* * *

A MID-WINTER SERMON.

We reprint a portion of a letter recently received, which contains enough truth to warrant the above title. There are too many cases like the one cited:

"In these troublous times of failures and assignments, a plain recital of a true story may be in order.

"A large concern in the metal manufacturing line, recently made a bad failure. The concern was made up of the sons of the original founder of the business, and the stock was owned by the sons and their sisters. To the surprise of the many, but not of the few who were in a position to notice things, the concern went under. One of the things that came to the attention of those in a position to notice, was that the concern had for some time been selling goods at less than the cost of making them, and as this became more widely known, the banks began to refuse the concern's paper; then came the failure, and with it, the "expose."

"Some time before the failure, the husband of one of the sisters 'smelled a mice,' and began to ask some questions at a stockholders' meeting; in consequence of which he was 'fired out' of the room. This, of course, only confirmed him in his suspicions, and he went back the next day and 'allowed' that he wouldn't go out that time until his wife's stock was bought and paid for by the brothers, and he didn't, and this daughter was the only one of the family whose stock was not a total loss to them.

"When the affair was investigated, it appeared that every one of the sons had been regularly and la.gely overdrawing their accounts, so much so that they had been practically running without capital, except the kind furnished by the concern of whom they bought their 'raw material' (which, by the way, was the other concern's finished product), which went into the goods sold at less than cost of production, as mentioned above.

"Of course the moral of this is: Don't overdraw your account; don't buy 'raw material' that you *know* you cannot pay for. In plain English, *don't steal*, even from yourself. If you must fail, fail honorably. In short, *be honest*. Do you suppose these brothers were *happy* while defrauding their sisters? Could any amount of money make a man happy when he knows it is stolen? Not taking into account the morality of the question, why not conduct a business in a way to bring happiness? A man must be about his business most of his time, and if he is not happy while about his business, what time has he left to be happy in?

"I don't believe a liar and a thief can be truly happy, do you? Verily the way of the transgressor is hard, and virtue is, even if oftentimes its only, its own reward."

MACHINING CYCLE FORGINGS.—I.

ONONDAGA.

The following is a description in detail of the method of machining the bottom bracket forgings that are used in the modern high grade bicycle of to-day, as practiced by a number of the larger manufacturers, and the proper method of designing the forgings is also illustrated and described, as well as the tools and special drilling jigs that are used in the different operations.

First, to begin with the design, supposing the finished connection is the size and form shown in Fig. 1, in which A is the end view and B the top view; the model for the forge shop must be made at least one-sixteenth of an inch longer than the finished piece, which allows one thirty-second of an inch to be faced off each end by the facing tool, which is described later. These two ends with the allowance for machining are shown by the dotted lines at C and D. The diameter of this same barrel must be made not less than one thirty-second of an inch larger to allow for the large drill that cuts out the center, running "out" a little as it reaches the bottom of the cut, as the hole is generally more than two and a half inches deep. This is also shown by dotted lines at E and F. This allowance permits as well of the outside forging being trued up with the hole after all the machine work has been done, otherwise the shell of the same would be thicker on one side than at the other, and would appear botchy.

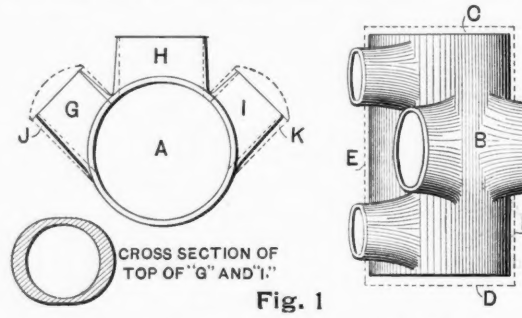


Fig. 1

The greatest care must be exercised, however, in designing this forging when locating the lugs into which the tubes of the frame fit, as they are all on angles from each end that must be absolutely correct when machined, or there will be a strain on the tubes that will not allow of their being brazed without springing the frame out of shape. This spring would also tend to open up some of the joints on one side, and they must be rebrazed before they are filed, or part of the work must be done over.

The end view A shows the four lugs, which are as follows: G is the one for the lower diamond tube, H for the seat pillar tube, I for the rear fork tubes, and as the two latter are directly in line, but one of them are shown. As the central lug H is the one that comes into one of the halves of the forging dies, it is only necessary to give it enough draft or taper to allow of the forging dropping easily out of the die when the drop is in operation. It will also be sufficient if the same allowance for finish is made that occurred at E and F, as the forging is always to be registered in the drilling jigs by this lug, and if the angle of the holes for the frame tubes are changed at any time to allow of a few special machines being built with the same forgings, this central lug will always be drilled the same and the changed angles will only affect the other three lugs.

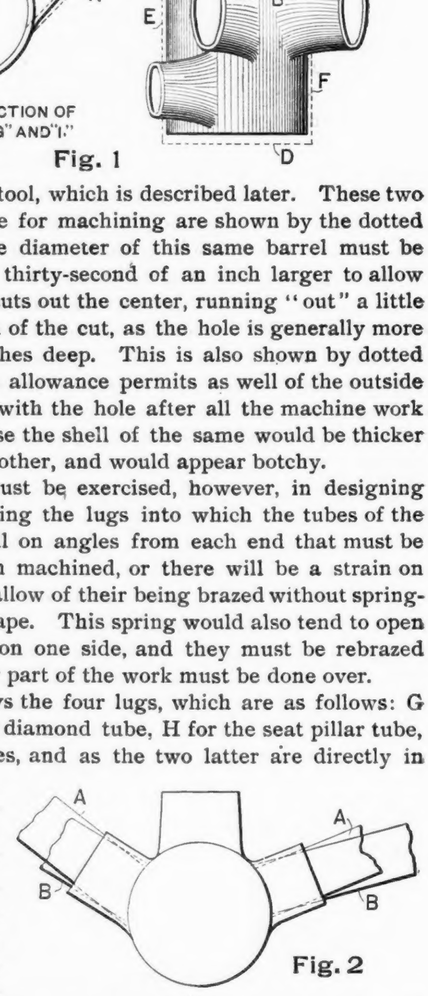


Fig. 2

The latter lugs G and I should be made so they are about the same diameter at the base of the part where it runs out into the main part of the barrel, that it will be when finished, and only a slight fillet left, as in filing the forging after the tubes have been brazed into place; these parts are very inconvenient to get at, and cannot be filed to the proper form without considerable trouble. The outer ends of them, however, must be made about one-eighth of an inch larger in diameter in one direction as shown, or even more if there is a possibility of being obliged to change the angles of the frame to such an extent that when the holes are drilled they will cut the shell out so much as not to finish up in filing. This extra stock is shown at J and K in both the top and side view cuts by the dotted lines, in which

it will be noticed the lugs have an oval form at the outer ends which gradually runs into the round base. This does not make any extra work in either machining or filing, as the sweep cutters take off the superfluous stock on the proper angle and leave the base of the lug round, the same as it was originally. From this, it will be seen that the holes for the tubes may be drilled on the angles shown in Fig. 2 at A, or as at B, and use the same forging, also the work of removing the stock will not cost any more if the jigs and tools are properly made than if the lugs were all made round and to the exact finished size.

The first operation of machining is to drill the large hole into the center of the forging. The tools needed for this are, first, a cast iron jig as shown in Fig. 3, which is a base plate with two vertical portions that are connected at the top by another plate into

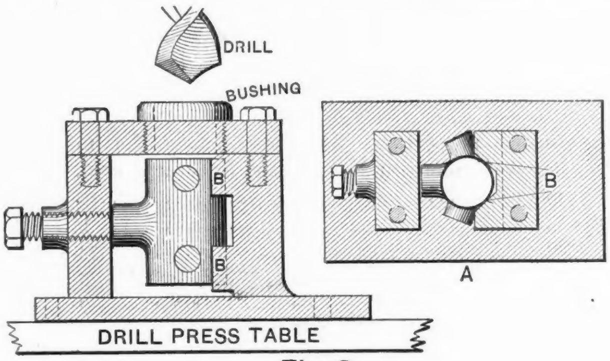


Fig. 3

which is screwed the hardened bush made from tool steel. This serves as the guide for the drill, and not only centers it when the cut is started, but supports it when partly through the forging and keeps it to a certain extent from running out to one side. If the bush were not used the drill would, even if started straight, tend to crowd to one side afterward, on account of the uneven surface on the end of the forging.

A, in the same cut, shows the top view of the same jig, with the cap plate off, and the surfaces at B are bored true with the center of the drill bush, and the center of the boring so formed is cut away to form a V. When the forging is held in place by the set screw shown on the opposite standard piece, the work is bound to center itself directly in line with the bush and under it. The screw that clamps the work in place should be not less than three quarters of an inch in diameter, or if there are many forgings to drill, the pressure applied and the number of times the screw is run in and out of place, will cause the thread to be worn considerably and strip. It should be hardened also, the entire

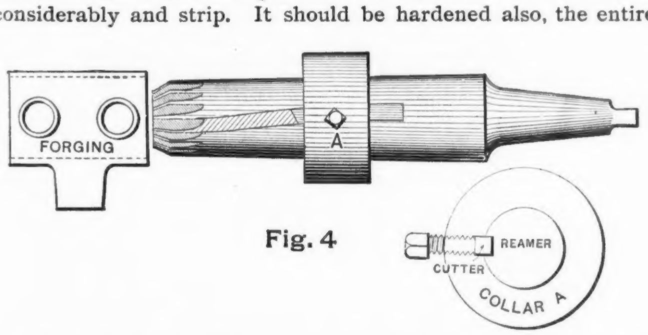


Fig. 4

length, or the head will be worn out of shape from the wrench, and the point when being turned under pressure will in time turn up at the edges and make it impossible to remove it from the standard when necessary.

The drill may be an ordinary twist drill of the usual length held in the spindle of the drill press by the taper shank. The drill press should be one with a powerful back gear and with power feed and automatic stop, as the operator can in this way run a large number of the machines.

After all the pieces have had all the hole drilled into them they may be reamed nearly to their finished size and have the ends faced off, by a long rose reamer, as in Fig. 4. The cast iron collar A is fastened on the body of the reamer by a set screw, and the collar has a slot in it lengthwise with the reamer, into which is inserted a square, hardened cutter, which is also held in place by a smaller screw.

The body of the reamer should have a shallow slot corresponding to that in the collar, so the cutter will be imbedded into it about one thirty-second of an inch. The slot will not only prevent the cutter from slipping around the reamer, but as the cutting edge of the cutter projects inside the face of the forging, it will prevent a burr forming, that would otherwise be rubbed up.

In doing the facing operation, the only holding jig that is needed is a hard wood block that will hold the forging approximately vertical and of such form that the piece cannot turn around when taking the cut, and at the same time the forging must not be held firm, or the rose reamer will not follow the hole straight. Let the reamer go entirely through the forging, and until the facing tool on its side has removed about one-half the extra stock that was left on the length of the piece, then turn it over and ream through the other way, letting the facing tool cut until it comes to a stop which has been previously set on the upper end of the drill press spindle. If the stop has been set right, the forgings will be all faced exactly the same length and will allow of their being placed in exactly the same position in the jigs for the operations that follow. The hole should now be a trifle under the finished size that it will be when the ball cases are placed in, it should also be a trifle longer, as when the frame is brazed, the forging is likely to be sprung out of true to a certain extent, and a scale is formed which must be again reamed out after all the brazing, filing, etc., is finished. These last operations, however, are often omitted when building cheap machines, forming one of the many causes for untrue bearings, as they are not very likely to be in line.

* * *

FROM ACTUAL PRACTICE.

A CRANKY NOTION.

"MILO."

Among the cranky notions to be found in the different shops, one is called to mind by "Notes from a Roving Contributor." Two brothers engaged in manufacturing have a small shop fitted up for experimental work, and to build the few special machines used, some of which are far more practical than elegant.

They will not allow steel or wrought iron to be ground on the emery wheel, on the plea that it spoils the wheel; grind-stone or file must be used for them, and the emery-wheel reserved for cast iron. I did not inquire how they managed other metals; cold chisel and hammers are probably used.

Perhaps I should explain that one of these machinists is a man who has a large hard-wood chest as well filled with a good assortment of tools as his head is with practical knowledge gained by his long experience as a "tramp machinist," which would make him a valuable man even if he didn't furnish the shop with nearly all the small tools used, files included.

On one of the machines built there, keen-edged discs were used for knives, each of which had a small emery-wheel attached, so that it could be ground while it was doing its full amount of work, which made the machine very efficient, as any adjustment was seldom necessary. Wouldn't it pay to furnish a special wheel also, to be "spoiled" by grinding odd jobs of wrought iron and steel?

Which will remove the *most stock*—a few dozen files or an emery-wheel of the same cost? Which costs the most, a mechanic to push a file, or steam power to run an emery-wheel, when the shavings (which must be disposed of) supply nearly all the fuel required, and the remainder can be had at the mill near by for the hauling and a mere song (sung by the teamster), the same amount to be removed in both cases? These are open questions to the file-makers, mechanics and emery-wheel manufacturers alike.

The proprietor of a small repair shop told me that he could make 60 cents an hour profit on almost any grinding job that came along, and that was twice as well as he could do with a file on the same work.

In problem 2 on page 111 of December, the type made me say "then by *dividing* the diametral pitch thus obtained," etc. It should have been "then *multiplying* the diametral pitch," etc.

* * *

IN studying any subject, whether steam, compressed air, or any other branch of mechanics, it is well to turn occasionally from theoretical results and find what has been done in practice. This is not to throw discredit on theory, but to learn what allowance must be made for every-day conditions.

SYSTEMATIC BOILER DESIGNING.—1.

H. M. Morris.

The design in the steam boiler is a problem in engineering which involves the careful consideration, application and solution of so many chemical and physical principles, together with the financial difficulties connected with each, that the writer feels he has undertaken no small task in attempting to give anything like a comprehensive idea of the subject in the small space allotted to this article; but it shall be his endeavor to, at least, point out the lines along which engineers are obliged to think and work in this branch of the sciences, the object being to indicate the mode of proceedure from start to finish, when considering the design of a complete boiler—a treatment not found in the text books. The principal authorities consulted are Thurston and Kent, both of whom are freely quoted.

It is required to design a boiler capable of evaporating 8,000 lbs. of water from 120° temperature of feed-water into dry steam at 150 lbs. gauge pressure when burning Maryland semi-bituminous coal with a good natural draught.

TYPE.

The choice of type of boiler is the first problem to be met by the engineer, and it is not one to be lightly passed over, since each type is adapted to its own special province. Where the cost of fuel is low, feed-water bad, or facilities for repairing poor, the plain cylindrical boiler is almost universally employed; where fuel is more costly and the feed-water better, the tubular boiler is adopted; and as the necessity for economy in fuel consumption becomes still greater, and the dictates of prudence demands the safest, the sectional, or "water-tube" boiler is selected, this being the only type that I consider suitable to place under a building—the installation of shell boilers involving too great a risk to both life and property.

The sectional boiler, with its smaller members and sub-divided steam and water chambers, is safe in proportion as the sizes of the latter are diminished; while the large shells of the common forms of boilers are liable to dangerous rupture in proportion as their diameters are increased. A water-tube boiler has the further advantage of better circulation, less weight and volume for equal powers, greater reliability in its details of construction, and is safe against disastrous disruptive explosions under all conditions of ordinary operation—a fact which cannot be said of any other form of boiler, so for the purpose of this paper we will consider the design of this type.

GENERAL SPECIFICATIONS.

The general specifications applicable to, and governing, the design and construction of all the standard forms of boilers are:—

1. To secure complete combustion of the fuel without permitting dilution of the products of combustion by excess of air.
2. To secure as high temperature of furnace as possible.
3. To so arrange heating surfaces that, without checking draught, the available heat shall be most completely taken up and utilized and the most complete and rapid circulation secured, both for the water and for the furnace gases.
4. To make the form of boiler so simple that it may be constructed without mechanical difficulty or excessive expense, and to arrange for ample water-surface, as well as large steam and water capacity, so as to insure against serious fluctuations of steam-supply.
5. To give it such form that it may be durable under the action of hot gases and of corroding elements of the atmosphere.
6. To make every part accessible for cleaning and repairs.
7. To make all parts as nearly as possible uniform in strength, and in liability to loss of strength with age, so that the boiler, when old, shall not be rendered useless or dangerous by local defects.
8. To adopt a reasonably high "factor of safety" in proportioning parts, and to provide against irregular strains of all kinds.
9. To provide sufficient safety-valves, steam gauges, mud-drums and other appurtenances.
10. To secure intelligent and very careful management.

WATER-TUBE BOILERS.

For water-tube boilers Mr. Robert Wilson gives the following points as requiring special attention, to insure their satisfactory working and durability.

1. To keep the joints out of the fire.
2. To protect the furnace-tubes from the sudden impingment of cold air upon them on opening the fire-door.
3. To provide against the delivery of the cold feed-water directly into the furnace tubes.
4. To provide for a good circulation to take away the steam from the heating surfaces.
5. To provide passages of ample size for upward currents, so that they may not interfere with downward currents.
6. To provide passages of ample size, for steam and water, between the various sections of the boiler, to equalize the pressure and water-level in all.
7. To provide ample surface of water-level to permit the steam to leave the water quietly.
8. To provide a sufficiently large reservoir for steam to prevent the water being thrown out by suddenly opening a steam or safety valve.
9. To provide against the flame taking a cut to the chimney, and impinging against tubes containing steam only.

This class of boiler is generally in use on land, but attempts have been made to introduce them for marine purposes.

PROPORTIONS.

The average proportions per horse power for maximum economy for land boilers fired with good Anthracite coal, are:

Heating surface	11.5	sq. ft.
Grates	⅓	"
Ratio of heating to grate surface	34.5	"
Water evap'd from and at 212° per sq. ft. HS. per hr.	3	lbs.
Combustible burned per HP. per hour	3	"
Coal with $\frac{1}{6}$ refuse, lbs. per HP. per hour	3.6	"
Combustible burned per sq. ft. grate per hour	9	"
Coal with $\frac{1}{6}$ refuse, lbs. per sq. ft. grate per hour	10.8	"
Water evap'd from and at 212° per lb. combustible	11.5	"
Water evap'd from and at 212° per lb. coal ($\frac{1}{6}$ refuse)	9.6	"

but in the course of our treatment of the subject we will find that these figures are not, by any means, infallible, their derivation being based more on trade custom than theoretical calculation.

The term horse-power, as here applied, means capacity to evaporate 30 lbs. of water per hour from 100° F., temperature of feed-water, into steam at 70 lbs. gauge-pressure, or 34.5 lbs. per hour from and at 212°, which is the accepted unit of measure of the capacity of a boiler. The measure of the efficiency of a boiler is the number of pounds of water evaporated per pound of combustible, the evaporation being reduced to the standard of "from and at 212°;" that is, the equivalent evaporation from feed-water at a temperature of 212° F. into steam at the same temperature. The measure of relative rapidity of steaming of boilers is the number of pounds of water evaporated per hour per sq. ft. of water-heating surface. The measure of relative rapidity of combustion of fuel in boiler-furnaces is the number of pounds of coal burned per hour per sq. ft. of grate-surface.

To ascertain the equivalent evaporation at any pressure, multiply the given evaporation by the factor of its pressere, and divide the product by the factor of the desired pressure.

$$\text{The formula for factor} = \frac{H - h}{966}$$

in which H is the total heat of steam at the observed pressure, and h the total heat of feed-water at the observed temperature. In our example $H = 1224$ and $h = 120$. Hence the factor of evaporation at 150 lbs. gauge and 120° feed is

$$\frac{1224 - 120}{966} = 1.1437$$

$$\text{and } \frac{1209 - 100}{966} = 1.1480$$

is the factor at 70 lbs. gauge and 100° feed. Therefore the number horse-power required to be developed by our boiler is

$$\frac{1.1437 \quad (8000 \div 30)}{1.1480} = 266 \text{ HP.}$$

FUELS.

The fuels used in engineering are anthracite and bituminous coals, coke, wood, charcoal, peat, and combustible gases obtained by the distillation of the solid kinds of fuel, all consist of either pure carbon or of combinations of carbon, hydrogen, and non-combustible substances. The heating power of any fuel is determined by calculating its total heat of combustion. This quantity is the sum of the amounts of heat generated by the combustion of the unoxidized carbon and hydrogen contained in the fuel, less the heat required in the evaporation and volatilization of constit

uents which become gaseous at the temperature resulting from the combustion of the first named elements. It is measured by what is termed the British Thermal Unit, which is the quantity of heat required to raise a pound of water from the temperature 39.1° to 40.1° Fahr. The heating power may be determined by three different methods, chemical analysis, combustion of a coal calorimeter, and actual trial of a steam boiler. The first two methods give the theoretical heating value, the third the practical value. Analysis and calorimetry give the most accurate results, and are usually taken as the standard by which the results of a boiler test are to be compared.

The heating power of a fuel is determined by calculating its total heat of combustion—an approximate estimate being easily obtained by the formula.

$$U = 14\,500\ C + 62\,500\ (H - \frac{O}{8}) \text{ in which}$$

C, H, and O are respectively the percentage of carbon, hydrogen and oxygen, each divided by 100, and U the number of BTU in the total heat of combustion of 1 lb. of coal. The value of U ranges between 5 500 for dry wood and 16 000 for the best known coals. Pure carbon contains 14,500 BTU.

A pound of Maryland semi-bituminous coal contains, carbon 80.5, hydrogen 4.5, and oxygen 2.7, therefore the total heat in

$$1 \text{ lb. is: } (14\,500 \times .805) + 62\,500\ (.045 - \frac{.027}{8}) = 14\,278 \text{ BTU.}$$

The efficiency of a boiler is the percentage of the total heat generated by the combustion of the fuel which is utilized in heating the water and raising steam, and depends not solely on the amount of heat generated, but also on the quantity and nature of the resulting products of combustion. The heating and the calorific power of a fuel are not necessarily the same; the heating effect depending only partly upon the calorific power of the fue burnt. A large part of the heat produced by combustion is expended in procuring chimney draft. Some is lost by incomplete combustion; some by coal dropping through the grate; some passes off with vapor, and still more is lost by radiation and conduction—the amount of heat thus expended being, in all cases, unavailable for producing useful effect. Then, too, a certain amount of carbon is required to heat the whole mass to the temperature at the furnace, which again reduces the calorific value of the fuel. The efficiency of any kind of coal is further dependent upon the amount of air supplied to the furnace in excess of that required to supply combustion. With strong draft and thin fires this excess may be very great, causing serious loss. With anthracite coal the heating value of the combustible portion is very nearly 14 500 B.T.U. per lb., which is equal to an evaporation of 14 500 thermal units. This divided by 966, the latent heat of steam at 212°, gives an equivalent evaporation per lb. of coal of 15 lbs. A boiler which, when tried with anthracite coal, shows an evaporation of 12 lbs. of water per lb. of combustible, has an efficiency of 12 ÷ 15 = 80 per cent., a figure which is approximately but rarely ever quite reached in practice. 12.5 lbs. of water per lb. of combustible from and at 212°, is about the highest evaporation that can be obtained from the best steam fuels in the United States (and there are no better coals in the world), although in one case 13.23 lbs. has been reached. With bituminous and the softer coals it is difficult to obtain as close an approach to the theoretical maximum of economy, as a great part of the volatile combustion portion of the coal escapes unburned. But, in regular practice, it may be considered safe to take the efficiency of good anthracite and semi-bituminous coal at 75 per cent., and of bituminous at 65 per cent. Hence we have 14 278 × .75 = 10 708.5 B. T. U. as the useful heating power per lb. of our coal.

* * *

It seems to be part of some men's nature to be everlastingly tinkering at the machine or engine they have in charge. A shop manager told me recently of a man he was obliged to discharge because he would not let his lathe alone. He could turn out more work than any man in the shop, but would spasmodically decide something was wrong with the lathe and rip it all apart. This is the reason some men have so much trouble with their wheels and other machinery which they handle, either at home or in the shop. For this reason some of the machinery which is completely boxed in and is without adjustment gives such good results; this baffles the tinker.

EVERY-DAY SHOP SUBJECTS.—3.

CORE-BOX PLANE—A STUDY IN LEVERS.

CHIPS.

One of the things which help keep a pattern-maker busy and not over happy is the half round core-box, especially if it is a good sized one. There is usually considerable guesswork about it unless there is a boring-bar rig, and that isn't found very often. It used to puzzle me when a cub, to see the pattern-maker take his tri-square and saw it back and forth in the core-box to see if it was half round or had high spots,

That was before I had learned that a right angle (or 90 degree) triangle will always touch a semi-circle at three points, namely, the two ends and a point on the circumference. In the language

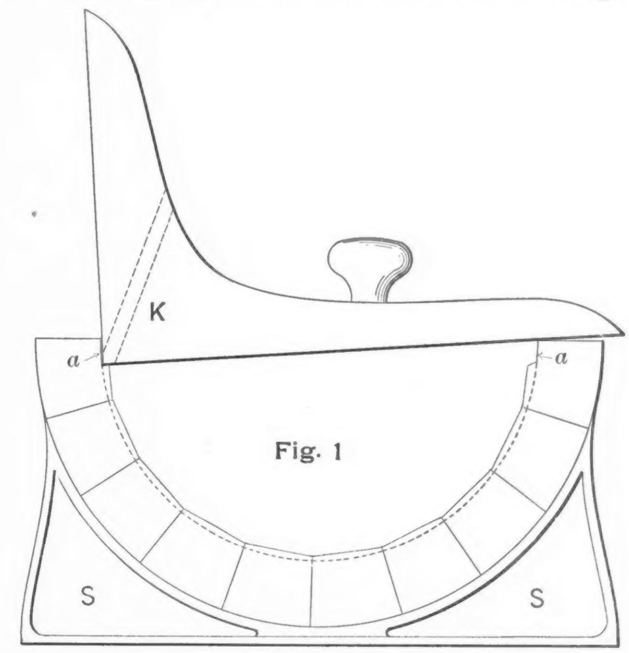


Fig. 1

of the geometry, an angle drawn through the ends of the diameters of a semi-circle and touching its circumference, is a right angle. This can be seen in Fig. 2, where the angles *a b b*, *a c b*, *a d b* and *a e b* are all right angles, being drawn according to the conditions named. This shows why the old pattern-maker knew more geometry than I did, and probably more than he was aware of at the time.

The other day I ran across a very neat application of this principle, which was very old, I was informed, but which I am sure will be new to a good many of your readers. At first sight I thought of "Milo's" man-killer described in the November issue,

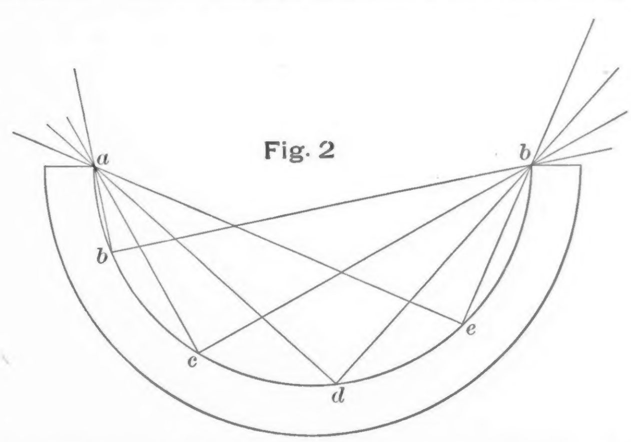


Fig. 2

and thought I had found its twin brother. But it wasn't; it was a plane being worked on a big half-round core-box, which was built up of sections as shown, and which was held by several supports like S S, being an iron casting of webbed construction. The plane body was a right angle, with the knife K going down through so as to present a good cutting edge. The edges *a a* were cut out with a gouge for a starting point, and the plane simply shoved back and forth, cutting a good chip, and following the line of a true half circle because it couldn't help it. It was only used half way around, then reversed and the other side cut down to meet it. Every man in the shop had a little one tucked

away in his tool kit, for small work, and all declared they beat a gouge all out, for both time and accurate work.

A STUDY IN LEVERS.

I give a sketch of a pair of cutting pliers with a toggle joint arrangement as in Figs. 1 and 2 of the cut, of which I was asked to figure out the leverage or the increase of power at the cutting edges B. A young friend of mine has been having quite a tussle with the problem, and has tried to figure the levers from joint to joint and from joint to power, as from A to *a*, *a* to *b*, *b* to *c* and *c* to cutting edge B. This is all right where there is any need of it, but in this case it is simply a case of results, of how many times the power applied at A is multiplied at B. In cases of leverage we find that the distance moved through by the long end, divided by the distance moved through by the short end gives the increase in power due to lever. Or if the long end moves 4 inches to a movement of 1 inch of the short end, then one pound at the long end will balance four pounds at the short end. Try it with a piece of wood or iron by balancing over a sharp edge at different distances, and you can easily prove that weight multiplied by distance from fulcrum or balancing point will be equal on each end of lever.

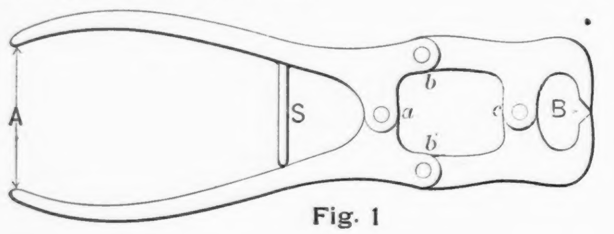


Fig. 1

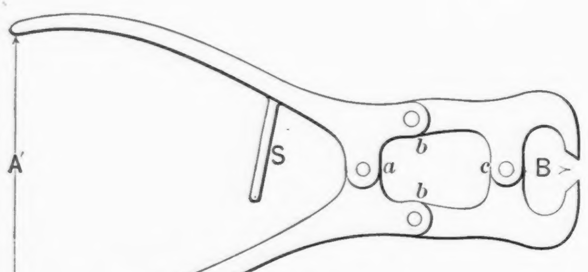


Fig. 2

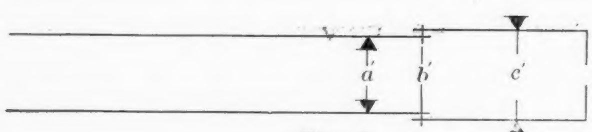


Fig. 3

We can also say that in this series of levers, the movement of the first divided by the movement of the last gives the increase of power due to the levers, without considering the intermediate levers at all. This is a point which, though very common and probably hundreds of years old, is apparently not known to mechanics generally, but which is an exceedingly useful one. In this case we just measure the distance A in Fig. 1 (when closed) and again at A', Fig. 2 (when open), the difference gives the movement of the first lever. Then measure the opening at B (which is practically zero when in first position) and divide the movement of A by the opening at B. The nippers shown moved 1¼ inches at A in opening ⅛ of an inch at B. Then 1¼ divided by ⅛ = 10, or as multiplication of power applied by this amount owing to decreased distance moved by B. Then a pressure of five pounds at A would give $5 \times 10 = 50$ pounds at B. To be exact, the movement should be taken at center of the applied power, which would probably be about 1½ inches from the end of the handles. Don't imagine the increase of power is clear gain, for it is accomplished only at a loss of distance moved, and it is well to remember that mechanical devices only *transfer power* from one point to another, and do not *create* it. Just think of this when your perpetual motion friend comes around.

* * *

THE W. C. Young Mfg. Co., of Worcester, write us: "We have made direct sales of over forty lathes thus far, and have received inquiries of importance from thirty more different parties abroad, from our first advertisement in MACHINERY, the issue of September this year. This is the best stroke in advertising that we ever did."

MATHEMATICS AND MACHINISTS.

ARTHUR B. BABBITT.

Do machinists need mathematics? This is a question the general reply to which would be in the affirmative, but how far in mathematics they should go would be where we would find the difference of opinion, although I have no doubt but what some of my machinist friends would tell me that mathematics were not required at all. This latter class I believe and surely hope are few and far between.

"Mathematics" is necessarily a broad term, and it would be well for me to state just what line the machinist needs. We will begin with arithmetic. Probably no man would say that this study was not necessary, and even should I ask my friend who does not believe in mathematics, if he understood arithmetic, he would probably reply: "Yes, arithmetic is all right, but I don't want any of this algebra." This answer is not imaginary, for I have actually heard the above reply made by a man who was remarkably well versed in the machinist trade. He could harden a piece of steel, and from his practical experience, together with a knowledge of the characteristics of the metal over which he was working, would make as nice a job as any accomplished blacksmith, and in other lines was equally as good.

It seems rather foolish to see a man make a statement which he bases partly on what he knows and partly on what he does not know. Take this man, for example, he had a knowledge of arithmetic and knew that it was useful; yes, knew that it was essential in order that he might solve the problems which arose in his daily work, and he based the first part of his statement upon this knowledge. Now let us look at the last part of this reply, "I don't want any of this algebra." Does he know what algebra is, and where it is used? I hardly believe he does, or he would have given the algebra credit for being useful in some places at least. Suppose we have a machine which is to be driven from a counter, said counter to be driven from the main line. How does he find the diameters of the pulleys to be used to give the required speed? I have seen men find them by trial, and it generally takes a long time, and in the end is not a satisfactory job, when by assuming the size of all but one, and using "x" for the unknown, we can very quickly and accurately find the pulleys to be used. This is only one simple instance of the many where a knowledge of algebra would be beneficial to the general machinist,

Some men reply, "You can have your mathematics if you want them; I want a good practical education, and I will leave the theory with you." Do they mean what they say? Doubtless they think they are perfectly truthful with themselves, but in the majority of cases they are not. Ask this same practical man how he does hundreds of things in the shop, and he will explain and give you in detail the theory; and yet he honestly believes he is a practical man, using the word "practical" in its most limited sense.

Shall the mechanic stop at algebra? My answer would be, "No; continue as far as possible." Geometry is very useful to machinists, and in laying out work I might say that it was necessary. The higher mathematics are also useful. My advice to machinists would be to get as much mathematics and theory as possible. Watch the men who tell you that a practical education is the only one necessary, and compare them with the workman who combines theory and practice, and you will find in the latter case a man who is destined to rise in his profession, and one who is trusted with the best work in the shop.

Ought a machinist to know how to make a drawing? To answer this may I ask, did you ever have an idea which you desired to illustrate and which you were unable to show clearly because you could not make a sketch? Did you ever have a drawing which you were unable to decipher? I have seen men who posed as competent men for any work, who would endeavor to illustrate an idea and in so doing would make a sketch having three views all in one, and which was entirely useless without an accompanying explanation, and then if the idea had complications the explanation needs be very exhaustive. In most places where the machine trade is carried on to any great extent, evening schools are provided where the rudiments of mechanical drawing are taught, which enables apprentices to get an education in this line which will advance them materially in their profession.

It may appear to some that the standard has been placed very

high, but there is an old proverb which is very applicable in this case: "What is worth doing at all is worth doing well." If this be the case, then a mathematical education is essential to success in the machinist trade.

* * *

NOTES FROM A ROVING CONTRIBUTOR.—5.

MORE GRINDING—A NOTE FROM THE PROFESSOR—PAPER-MAKING AND CALENDER ROLLS—J. MORTON POOLE—A BAFFLED ASTRONOMER—FAILURE OF AN AUDIENCE—A CHANCE FOR THE READER.

I promised in the last section of my notes to say something more of the Poole system of grinding, and sent the draft of my notes to the Professor, who writes:

"Considering the relation I bear to the Editor and yourself, as well as my reputation in the scientific world, I must accept your notes on the Poole system of grinding as a kind of insult. There is nothing inexplainable in mechanics or dynamics, and if so it should not be admitted. Then again, that tale about J. W. Nystrom! Why, Nystrom, a friend of mine, was an astronomer, and to think of his being puzzled over a sloppy grinding machine. It is all bosh. The aberrations of mind indicated by your copy suggests close attendance on the beer cellars, and I return it without submitting it to the Editor. Go more carefully in the future.

"THE PROFESSOR."

Here is a pretty mess; copy I had labored over, thrown out blue-penciled and returned to me. Well, I must admit some embellishments thrown in especially for the Professor to cut out, but he has demolished the whole. Here is the copy, rewritten, it is true, and sent over his head to the Editor.

J. Morton Poole was a gifted man of Quaker lineage, a relative and connection of the Sellers families, who in early days had paper mills along the Brandywine Creek, a stream that empties into the Delaware River at Wilmington, and now employed mainly in driving Dupont's powder machinery there.

It is classic ground thereabout and thick with traditions of the Revolutionary period, also of the settlement of the Swedes there, who fought the Dutch of New Amsterdam, now called New York. They named the creek "Christiana," in honor of their erratic Queen, daughter of the great Gustav Adolph and the only woman that crept through a rent in the Sallic law which was made in 1560.

In making paper there are employed calender rolls, to compact, dry, form and finish the film into a web, from a hundredth to a thousandth of an inch thick, three to six feet wide.

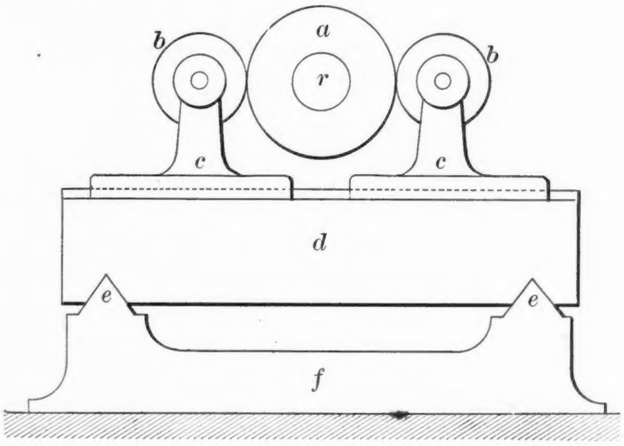


FIG. 1.

Just imagine a web of elastic material of this thickness being drawn by rolls! A variation of a thousandth of an inch would pucker the sheet. Calender rolls must be perfect and not show a line of light between them when piled up ten feet high and six to seven feet long. This means one five-thousandth of an inch, if anyone can conceive of what that is.

Such rolls down to Mr. Poole's time had been made by guide grinding and lead laps, if the reader knows what that is. A "lap" is a collar of lead or copper passed over the rolls with emery and oil so as to produce a precise parallel, which it did after a long time and much expense, but the rolls so made were not "straight," a thing just as important as true parallelism.

Mr. Poole conceived of, dreamed of, or somehow invented a new process of "straight" grinding. It has always been a problem where the original concept came from, and the reader can guess for himself when I explain what it was. There were no premises of precedents.

He went to the paper-makers and told them he could grind their calender rolls straight at half the usual cost, but had no money to prepare the machines, but if they (the paper-makers) would furnish the means to construct the machinery, he would contract to grind out the sum advanced at half the rate then being paid for rolls. They agreed to this, and the ingenious inventor went to work and constructed the machines, very much as they are now, at Wilmington, at Leith in Scotland and on the Continent in Europe.

Now if the reader will assist by close attention, I will attempt to explain what was done, with the aid of the diagrams, Figs. 1 and 2, referring first to Fig. 1.

Suppose *a* to be the end of a calender roll and *b b* grinding wheels mounted on the movable stands *c c*, these latter gibbed to a heavy slide *d* traversing on the ways *e e* of the bed frame *f*.

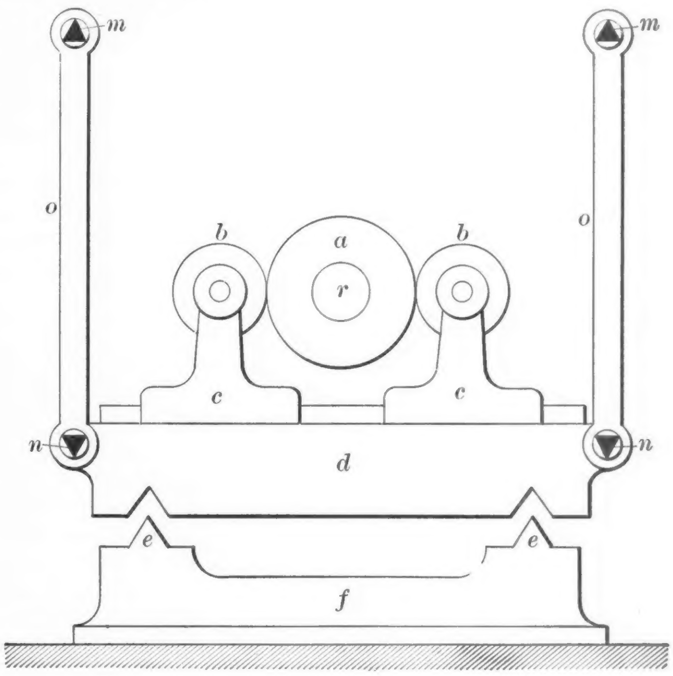


FIG. 2.

Suppose the wheels *b b* are set up in contact with the roll *a* and traversed along by the carriage *d*, the roll would be ground round and parallel in so far as the guidance of the ways *c c* would determine, and so far as common slide-rest processes admit, but this will not do. Rolls so made are not true. The ways are not true. In short mechanical guidance fails in this instance.

Next refer to Fig. 2 and imagine the carriage *d* raised clear of the ways *e e* and suspended on links *o o* resting on knife-edges *m* and *n* at the top and bottom, free to swing with a touch, or with a breath almost. The wheels *b b* being tenderly set up by striking their adjusting screws with a little mallet made of pine wood, so as to touch the rolls at each side, and the carriage *d* traversed as before; what will take place? The wheels act like a pair of calipers or a "lap," guided laterally by the roll itself. The result is absolute parallelism and the first condition is filled.

But what about straightness? The roll *a* is in revolution, running on its gudgeons *r* at each end, not on centers. Suppose it was not straight, what would take place? The carriage *d* with its mountings weighing a ton or more, could not be jerked from side to side 150 times a minute or even ten times a minute, to accommodate a variation of the roll's allignment. Consequently the carriage moves true to the ten-thousandth of an inch, and the roll straightens itself by a guidance that may be said is derivable from its own "axis of rotation," a theoretical line of absolute truth.

This is one of the most simple things in the world to "see," and the result seems obvious, but when one "rises to explain," then the difficulty begins. I am not going to explain it, for the best of reasons. Mr. Poole tried to explain it before the Franklin Institute, thirty years ago, and failed; that is, the audience failed to understand. Mr. Poole was all right in his part.

Mr. J. W. Nystrom, a Swedish engineer of wide reputation, the author of Nystrom's Pocket Book, went down to Wilmington

to see the process, watched the machine half a day and came home discouraged. He went again the next day and gained a conception of the puzzle and the physical elements involved, so he claimed, and he did, no doubt, because he was a foremost mathematician of his time.

Mr. Poole went over to England and got laughed at as a crank, by several firms he presented the scheme to, but he met a Scotchman at Leith who, by "canny considerin'," caught the idea and made money by so doing. In Germany the thing was fascinating, was adopted and there is no doubt a treatise on the subject there of several hundred pages.

The Poole patents have long ago expired and were never of any use in this country. I imagine there is not a grinding machine of the kind on this continent outside of the works in Wilmington, unless made there. Some inventions are too deep to be understood or infringed.

I wonder what the essayists on the "inventive faculty" will do with this case. It is not an evolution of experience, certainly not an emanation of skill, but is pure invention or inductive inference qualified by skill, which term I here set up as a definition of invention and dare the Professor to argue it with me.

What a round this grindstone matter has led up to; I had no idea of it, and am not done by any means, but it is growing stale, as I infer by a mark of the Editor on the last proof, where he wrote "switch," so I will "switch" to "clutches."

There are many of these scattered all over the machine field, good, bad and otherwise, and only one perfect one in the lot, or at least one better than all the rest. What this one is will appear in the next article.

* * *

MACHINE DESIGN.—2.

JUNIOR.

Many systems have been devised for keeping the records necessary in a drawing room, and while a system may appear complicated to one unfamiliar with its use, still to those who use it, the desired end may be achieved to their satisfaction.

I presume that many machine builders have their drawings made on manilla paper, and then tracings on linen made from them, and some preserve both the manilla paper drawing and the linen tracing.

The method now pursued by one of the largest machine tool works in America, is to use in place of manilla paper and tracing linen, Crane's No. 21 bond paper, penciling and inking the drawings direct on it, and it is so transparent that good blue-prints may be made.

Blue-prints made under bond paper require more time for exposure in the print frame, but are generally as good as those made under linen.

The writer has worked in offices where both methods were pursued, and has never had any desire to use linen where it was possible to use bond paper.

The question of storing and indexing drawings is one of a great deal of importance, as it is necessary to preserve them in such a manner that it will not be difficult to find them when they are required. Some persons prefer a continuous number series for drawings, patterns, etc., while others make the drawing and machine detail numbers complete for each machine, and some trust in no small measure to good luck for their systems. As it is much easier for one to criticise than to reform, and as the main object in view in all commercial and manufacturing organizations is to earn money for the promoters, therefore if the object of its existence is achieved, then the systems under which its success is accomplished are generally such as are best suited to the training and temperament of those who have to work with them.

The system with which the writer is most familiar is one in which the drawing and machine details are numbered consecutively and are complete for each machine, and the method of filing the drawings is to place them in separate folios, and return folios which have been in use during the day, to the fire-proof vault at night. One of the advantages of portfolios is that it places the drawings in a conveniently portable shape, so that when the drawing for any particular machine is wanted, by referring to a general index book kept for recording a general description of the drawings made, any attache of the office may be sent to the vault and he usually succeeds in producing the desired folio, provided due care has been exercised by the one who has last used the drawings, to replace them in their proper folio. When portfolios are used, all the large size sheets must be folded so as to conform to the folio size, but that has not proven to be much of a calamity.

There is much difference of opinion as to the manner of designating the machine for which a drawing has been made; some firms using only a letter and figure or combinations of these, and keeping an index either in a book or on cards; but I believe that the drawing should tell its own story, and if it does take more lettering on the drawing, you will always have the index where it should be.

As the names and numbers of the details of a machine generally originate in the drafting room, a list may be prepared for use in the executive offices, in which the name, number, amount wanted and pattern used are entered thereon. This list may be extended to contain also the numbers of the sheet on which may be found the drawings of the pieces.

Where due care has been exercised in the making of drawings, lists and orders, it will usually prove both time and money well spent and cause less confusion than would be the case where little attention is paid to such matters.

As I believe that this branch of mechanical work has not been written upon as much as its importance deserves, I trust that we may hear more concerning it from other readers of this paper.

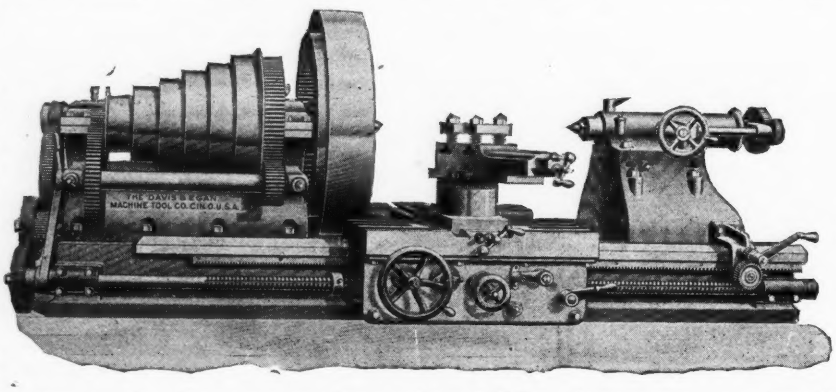
* * *

LARGE ENGINE LATHES.

The accompany engraving shows the latest engine lathe of the Davis & Egan Machine Tool Co., Cincinnati, O., which is made in 52 and 60 inch sizes. As is usual in lathes of this size, the bed, which is heavy and well braced, rests directly on the foundation. Rigidity has been made one of the main features, the head-stock being of box form and webbed for stiffness; the tail-stock is provided with long bearings as well as the carriage, so that vibration should not occur in ordinary usage.

The spindle is of high grade steel and is ground after being turned to shape. It runs in phosphor bronze bearings, and special attention is paid to lubrication.

The carriage has a full length bearing on three V's, all of which are scraped fits, providing against vibration at this point. The apron is double, enabling shafts to run in two bearings.



Gears are cut from solid and driven from screw, an automatic stop being provided so as to throw out the carriage feed at any desired point. Change gears allow threads between, one-half a thread per inch (2-inch pitch from center to center of thread) to 12 per inch, including 11½ per inch for pipe threads.

* * *

THE BROWN & SHARPE MFG. CO., Providence, R. I., announce the issue of new editions of both "Formulas in Gearing" and "Practical Treatise on Gears," which contain much information due to recent investigations, and not heretofore published. "Formulas in Gearing" now contains 82 pages 6x9 inches, and costs $2.00. "Practical Treatise on Gears" has been increased to 156 pages of the same dimensions, and costs $1.00 in cloth, or 75 cents in cardboard. These are both practical books, written especially for men whose work necessitates a clear understanding of gears and their construction. Elaborate mathematical formulas are omitted, and all points are made as clear and simple as the subject will admit. They form a valuable addition to any mechanic's library.

(CONTINUED FROM PAGE 142.)

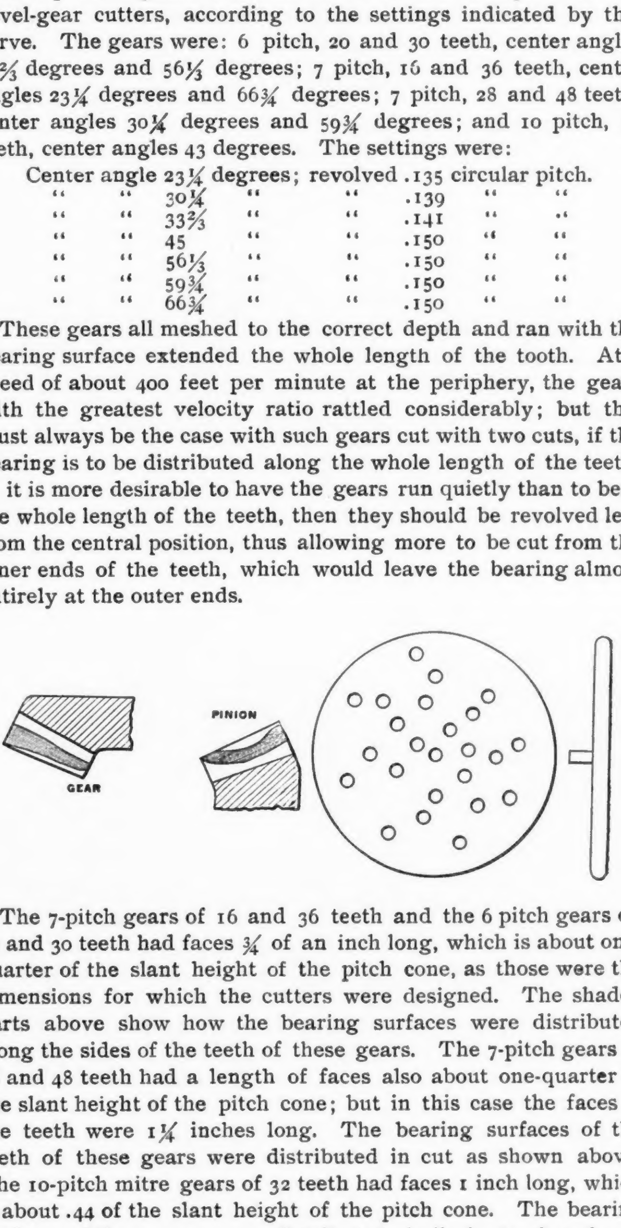
A. S. M. E.

A study of the problem led to the supposition that the amount a gear must be thus revolved could be expressed in terms of the pitch, the coefficient being a variable depending upon the center angle of the gear, which is here taken as the angle between an element of the pitch cone and the axis of the gear. It was also thought that this angle through which the gear must be revolved must be independent of the pitch of the gear; for, with a given pitch cone to be provided with a certain number of teeth, any pitch may be given to the resulting gear by selecting the base of the pitch cone at the proper distance from its apex to give the gear the required pitch diameter, since the pitch diameter of a bevel gear is measured on the larger end of the gear. And it is obvious that the setting which will answer for cutting a gear taken from one part of this cone will answer for cutting a gear taken from any other part; yet the two gears would be of different pitches.

Four pairs of gears were cut with Brown & Sharpe's involute bevel-gear cutters, according to the settings indicated by this curve. The gears were: 6 pitch, 20 and 30 teeth, center angles $33\frac{2}{3}$ degrees and $56\frac{1}{3}$ degrees; 7 pitch, 16 and 36 teeth, center angles $23\frac{1}{4}$ degrees and $66\frac{3}{4}$ degrees; 7 pitch, 28 and 48 teeth, center angles $30\frac{1}{4}$ degrees and $59\frac{3}{4}$ degrees; and 10 pitch, 32 teeth, center angles 43 degrees. The settings were:

Center	angle	$23\frac{1}{4}$	degrees;	revolved	.135	circular	pitch.
"	"	$30\frac{1}{4}$	"	"	.139	"	"
"	"	$33\frac{2}{3}$	"	"	.141	"	"
"	"	45	"	"	.150	"	"
"	"	$56\frac{1}{3}$	"	"	.150	"	"
"	"	$59\frac{3}{4}$	"	"	.150	"	"
"	"	$66\frac{3}{4}$	"	"	.150	"	"

These gears all meshed to the correct depth and ran with the bearing surface extended the whole length of the tooth. At a speed of about 400 feet per minute at the periphery, the gears with the greatest velocity ratio rattled considerably; but this must always be the case with such gears cut with two cuts, if the bearing is to be distributed along the whole length of the teeth. If it is more desirable to have the gears run quietly than to bear the whole length of the teeth, then they should be revolved less from the central position, thus allowing more to be cut from the inner ends of the teeth, which would leave the bearing almost entirely at the outer ends.



The 7-pitch gears of 16 and 36 teeth and the 6 pitch gears on 20 and 30 teeth had faces $\frac{3}{4}$ of an inch long, which is about one-quarter of the slant height of the pitch cone, as those were the dimensions for which the cutters were designed. The shaded parts above show how the bearing surfaces were distributed along the sides of the teeth of these gears. The 7-pitch gears of 28 and 48 teeth had a length of faces also about one-quarter of the slant height of the pitch cone; but in this case the faces of the teeth were $1\frac{1}{4}$ inches long. The bearing surfaces of the teeth of these gears were distributed in cut as shown above. The 10-pitch mitre gears of 32 teeth had faces 1 inch long, which is about .44 of the slant height of the pitch cone. The bearing surfaces of these gears were distributed similarly to that shown for the pinion in the figure.

The exact setting desired cannot usually be obtained on the ordinary dividing head of a milling machine, so the spacing device shown in Fig. 5 was made. It is a circular plate $\frac{1}{8}$ of an inch thick, with a pin in the center which fits in the holes of the index plate of the dividing head of the gear-cutting machine, and has a series of holes of the size of those in the index plate, arranged in a spiral. The required partial revolution of the gear to obtain the correct setting is reduced to decimals of a revolution of the index plate. Suppose this requires .125 of a revolution of the index plate, as was the case with the gear of 48 teeth The index plate used had 20 holes in the outer row, which makes two and one-half of its spaces correspond to the required .125 revolution. Therefore the pin on the spacing plate was inserted in the hole in the index plate second from the one in which the locking pin of the dividing head had been inserted, and then the index plate was turned till the locking pin entered the proper hole in the spacing plate, which, of course, in this case, was at a distance from the center pin of the spacing plate equal to one-half of the space between consecutive holes of the 20-hole row of the index plate.

CONVENTION CHAT.

Speaking of the large ratio of expansion between high and low pressure cylinders, Mr. Rockwood, who was the pioneer in this line of work, told of a rather surprising phase of the subject which had just cropped out in his practice. He had designed a comparatively small compound with a ratio of 1 to 6, and which ran normally at 183 revolutions per minute, and designed for 150 pounds of steam. The condenser had not been connected and as the full load was not thrown on, the engine was run non-condensing with 115 pounds of steam.

Wishing to see whether the low pressure cylinder was doing any effective work under these conditions (which are usually cited against large ratios), he disconnected the low pressure piston, and found that with 150 pounds of steam the engine could not get up to more than 175 revolutions, proving conclusively that, even under these adverse conditions, the large cylinder was of considerable use instead of a detriment, as claimed by many.

Referring to the limited use of economizers in America as compared with England, the same speaker thought the explanation lay in the great difference in the cost of boilers. In England, with poor water in so many places, the only boiler which gives good satisfaction is the Lancashire type, which costs about four times as much per HP. as the boilers we use, and about three times the cost of economizers there. It is better economy for them to use as little boiler and as much economiser as possible, while in this country the conditions are reversed.

Mr. Platt referred to the bad water in England, and cited cases where he had seen scale six inches thick inside boilers. Here is a field for anti-scale liniment.

In one of the discussions concerning boilers, Mr. Kent mentioned the Centennial Test, and the official report which placed the Babcock & Wilcox near the top of the list was declared erroneous by Mr. Le Van, who helped make the test, never leaving the boiler-room from start to finish. Mr. Le Van claims, and apparently has good evidence to back it up, that their correct position was eighth on the list, and that the reason was an incorrect accounting of water used, Mr. Babcock claiming to have evaporated one tank more than was actually the case. The committee allowed this claim, which resulted in placing this boiler much higher on the list than it should have been.

* * *

CRITICISING THE MANAGEMENT.

Been There.

Some managers are much annoyed by the criticisms of those under them; every shop has its growlers who talk about things that do not concern them, and this often makes the manager mad. It is the same old story of the subscribers knowing better than the editor how a paper should be conducted.

After a while the manager gets mad and "fires" the premier growler, and very often he makes a mistake in doing so. The manager says the growler is a fool, and that he will not have him around any longer; but, often a fool can make some very pertinent criticisms.

Of course the growler doesn't go into the manager's office and tell him that he isn't running things right: he simply says to some one, who repeats it to the boss, who repeats it to some one else, so that it finally reaches the manager's ears, that "if the old man knew anything he wouldn't paint that machine red, but would paint it green instead."

In the first place, if the manager wants to stand on his dignity, why should he pay any attention to what a common growler says about him, anyhow? In the second place, if the manager is running the place to make money, rather than as a frame for his dignity, why not sit down and consider if there is any foundation for the criticisms of the growler?

The man who runs a machine, for instance, if he doesn't know enough to know anything *but* how to run the machine, is, from the very nature of the case, often more likely to see "points"

about the machine than some "smarter" fellow who is expected, from the nature of his position, to know everything.

I have more than once puzzled myself over some problem, to be set right, at last, by some growler who was intimately connected with the matter. Did I "fire" the growler? Not much! I am just hog enough to make use of all the good suggestions I can get, and the more the growler growls the better I like it, if I can get any good out of it.

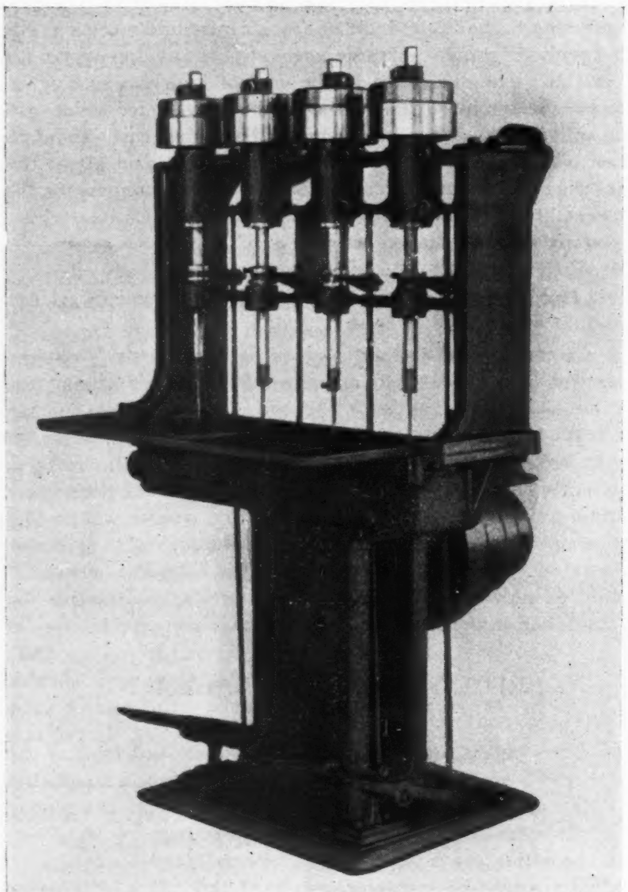
Men will talk, anyhow; if you "fire" one growler, another will take his place. Never mind what a man *says*—it's what he *does* that counts. Anyone can surround himself with a lot of flatterers, if it pleases him to do so, but what is gained by so doing? If you don't know the answer to this question, ask the stockholders.

* * *

ACME FRICTIONAL TAPPER.

Those familiar with the large variety of bolt and nut machinery made by the Acme Machinery Co., Cleveland, Ohio, will not be surprised to know of a further addition to their line in the shape of a very neat four spindle frictional tapper, which was designed to tap square and hexagon nuts from 1/8 to 3/4 inch in diameter.

The four spindles are driven by one belt passing half way around each pulley, forming a loop between each pair of spindles by means of idlers, which are adjustable to take up slack of belt.



The friction pulleys are of sufficient weight to keep them in contact with the belt pulleys, giving ample power for tapping within the range of the machine and obviating the use of mechanism to get out of order. The raising and lowering of the spindle is controlled by the treadle, and the taps can be readily taken from the machine to remove the nuts from the shanks of taps. The machine is capable of turning out more work than the ordinary belt tapper or automatic machine, and the compactness of the machine itself, as well as the small floor space required for a group of them, will commend it to those in need of nut tappers.

* * *

General Traffic Manager Randolph, of the Baltimore & Ohio South-western, is paying considerable attention just now to the development of the local industries along his line. For a number of years the Baltimore and Ohio South-western has fostered its local industries and endeavored to place them on a paying basis, by promptly furnishing cars, etc., for their convenience, but still further efforts are to be made. Coal Traffic Manager W. W. Peabody, Jr., has been placed in charge of this department, in addition to his own, and it is expected that the Baltimore and Ohio South-western will add greatly to its revenues by securing new manufacturing industries to locate along its line of railroad in Ohio, Indiana and Illinois. This road has a great advantage in being able to furnish very cheap fuel.

* * *

MUSHET STEEL MILLING-CUTTER.

We have been favored with a milling-cutter from the L. S. Starret Co., of Athol, Mass., which is interesting to any one who has ever handled a milling-machine or followed the progress made in this line. This cutter is of Mushet or self-hardening steel and was designed for milling tempered saw-plate steel. The various operations necessary to produce a milling-cutter give evidence that the difficulties of machining this kind of steel have been overcome by annealing.

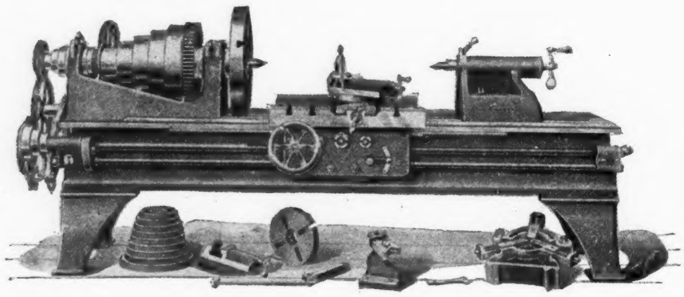
Mr. F. J. Gay, who has charge of this department, informs us that after thorough annealing they have no trouble in using the same tools as are used for ordinary annealed tool steel, and our own observations in this department showed that the annealing must be thorough, for the speed of the milling-cutters was considerably greater than we usually find.

Owing to the difficulties experienced in grinding the teeth, these cutters have not been advocated for general use, but in cases like this—for milling very hard stock, they work very satisfactorily. It is such details as these that make or mar the success of the machine which is to use them.

* * *

SPRINGFIELD-MULLER LATHE.

While this follows the lines of the other sizes of engine lathes built by the Springfield Machine Tool Co., Springfield, O., there are points of interest which are worth noting, especially the principal dimensions which indicate that ample metal and wearing surfaces have been provided. The spindle is of crucible steel, with the collar forged on. The hole through it is $2\frac{1}{16}$ inches, admitting 2-inch rough bars, which is one of the important features in a modern lathe, where so much work is cut from the bar instead of separate forgings as formerly. The front spindle bearing is of good size, 4 by 7 inches.



SPRINGFIELD-MULLER LATHE.

The carriage is 32 inches long, has full bearings on the ways and is gibbed to outside of bed. The cone is five step for 3½ inch belt.

The handle shown in front of lead-screw box at head end of lathe must simply be turned to the right or left to respectfully engage the gear or belt feed, or *vice versa*, without the necessity of disengaging the change-gearing or removing the belts. A very desirable combination is secured by this device, its construction making it possible to give the belt any required tension necessary to perform its duty without slipping, and as the belt may be made endless, the annoyance from breakage and re-lacing are entirely avoided.

All parts subject to abrasion are case-hardened. When desired, an improved taper attachment is provided, which will turn tapers up to 4 inches to the foot.

* * *

Next to Edison, who is noted for the number of patents he has taken out, Mr. Francis H. Richards, of Hartford, Conn., is the most prolific inventor in this or probably any other country, having taken out over 430 patents, about 90 of them in 1896, which shows that hard times stimulate the inventive faculty. Mr. Richards has also an extensive practice in patent cases, numbering among his clients the Pratt & Whitney Co., Billings & Spencer Co., and many other well known manufacturing concerns.

COMPRESSED AIR FOR HOISTING PURPOSES.

JOHN L. KLINDWORTH.

As it seems likely that we shall soon have more business to look after, I wish to say a few things in regard to hoisting and lifting apparatus, for in this particular quite a number of improvements might be made. In visiting foundries, the one thing I have most often noticed is the inadequate provision made for lifting and handling light loads, up to say 4 or 5 tons, quickly and economically. Usually, one finds the slow hand crane, or the still slower chain block.

Of course one can say nothing against their safety, or the fact that the pattern may be drawn with any desired speed from zero to the limit; but there are other means for doing this as well, much quicker and by far more economically, and this is by means of the air-hoist. This, in the writer's opinion, is about the best way to handle varying loads.

The only system that could approach this is, perhaps, the hydraulic system, but this possesses some undesirable features, such as leakage of valves and stuffing-boxes and freezing up, if precaution is not taken in draining pipes.

Another point that may be mentioned in favor of the air-hoist and the necessary compressing plant, is the low cost of installation and flexibility of the system.

The electric system, although suitable for traveling cranes and cranes of capacities over, say 5 tons, is not "in it" so to speak, when compared with the air-hoist for light loads. The efficiency is not nearly as high, the cost and maintenance considerably higher, the hoisting and lowering, slower. The steam crane need hardly be mentioned, for it is becoming too well known as a profit-eater.

The power-crane, when well made, does very well, still the cost of operation and the first cost, is greater than that of the air-hoist. Returning, now, to the points raised in favor of the air-hoist over hand-crane, the rapidity with which it works can be first considered. Taking a load of 2 tons, to be lifted by a hand-crane 3 feet and lowered again. This would require two men at the crank, and would occupy in ordinary working about five minutes. With the air-hoist one man could perform the same operation, with no exertion except pulling a chain, in at least one-third that time.

This is quite an item, for usually one or more moulders are delayed with their work by having to wait until their neighbor is done with the crane, which means additional expense (due to lost time) to the cost of casting.

As regards the cost of hoisting by hand-crane and air-hoist, we will assume the case before mentioned. A load of 2 tons to be lifted 3 feet and then lowered. This would require two laborers at the cranks and one moulder at the hook. Wages for 5 minutes, two laborers, 2½ cents; moulder, 2¼ cents=4¾ cents. This, of course, does not take into consideration the time lost by one man leaving his work and resuming it again.

For the air-hoist, operated by the moulder and helper, assuming it would require but ⅓ the time necessary for the hand-crane, would amount to .4 cents for one laborer and .75 cents for moulder, and air .05 cents; total of 1.2 cents or about ¼ of that for hand-crane. Of course, it will not always require three men for the hand-crane, but neither will it always take two men for the air-hoist. Then, again, for heavier loads it may require from four to five men (who will have to leave their work) for the hand-crane, where, as two men are all that are needed for the air-hoist. To sum up, it can be readily shown that the air-hoist is much quicker in operation, which is, perhaps, the most important item—and further, that the cost of operation would be about one-third of that for hand-cranes.

Coming to cost of installation; considering the cost of frame work for either kind of crane the same, it would cost about $100 to fit up a hand-crane, while an air-cylinder would cost about $75 at the outside. Of course a compressor, receiver, and pipes, would have to be bought, but these would not amount to more than $475.

Assuming that we need three cranes, it would cost, at the least, $300 to put gearing, chain, hook, etc., on them. For the air-hoist it would be $225 and $475 for compressor and tank; total of $700, or $400 more than hand-cranes. This at 6 per cent. interest, together with depreciation of compressor, etc., can be taken at $35 per year.

This would be saved by air-hoists over hand-cranes after 1,000 lifts had been made. After that it would be simple gain, and one would have cranes of three times the capacity of the hand-cranes.

As the compressor would probably compress air for six or more cranes (depending, of course, upon the number of lifts made in a given time), other uses could be found for the compressed air—such as hoisting metal to cupola, charging floor, or for a drop, sand-sifter, etc.

To anyone desiring to put in the compressed air plant, a few notes in regard to it may be of interest. The most desirable compressor for a small plant is undoubtedly the one which is belt-driven from a line shaft. The belt is shifted on or off by an automatic device as the pressure in the receiver falls or rises. There are several firms making this style for from $300 to $400.

The receiving tank should be about 3½ to 4 feet in diameter, by 8 feet high. A good-sized receiver is advantageous, in that the pressure will not fall so quickly should several hoists be lifting at once. The supply pipe should be connected to upper portion of the tank, as considerable water will gather in the bottom of tank, which must be drained off occasionally.

The supply pipe may be 1¼ to 1½ inch. diameter—this is ample. The precaution should be taken when putting up the pipe to make sure that no joints leak, for quite a large amount of air will escape in a day when under pressure of 80 lbs. per square inch, and leaky joints are hard to find, for air does not show as steam does.

There are a few points to mention in connection with the hoisting cylinders:

The hook should not be a part of the piston rod, but should admit of being turned on it. Often it is desired to twist the load a little when suspended, and this cannot be done easily if the hook is part of the rod, for usually the friction of the piston prevents it. Of course, the chain may be twisted, but this is not desirable as it always tends to regain its original position.

The best valve for operating hoist is undoubtedly the 3-way cock, for it admits of being opened very gradually, which is very desirable with air hoists. The levers for each should be considerably longer than mostly made—about 9 inches long if circumstances permit.

For best work the cylinders should have a very smooth bore; the smoother the surface the more satisfactory will be the results in hoisting. The thickness of metal in cylinders may be the same as for standard water-pipes.

The size of pipe on cylinder should not be less than ½ inch diameter for a 19 inch cylinder, this gives speed enough. For smaller cylinders, pipes of smaller diameter may be used if desired.

Below is a table that gives the loads which may be raised, assuming air compressed to 80 lbs. per square inch, also the number of cubic feet of free air required for a lift of 1 foot for the respective diameter. For ordinary work, a lift of from 4 to 5 feet will be found sufficient. Multiplying the figure in the last column, opposite the diameter of cylinder in question, by the height of lift desired, will give the number of cubic feet of free air required for a load equal to the capacity of the hoist. For lesser loads the quantity of air required will be correspondingly less. Knowing the probable lifts to be made in an hour, it will enable one to determine the size of compressor necessary. In most cases, however, it will be advisable to install a compressor, as mentioned above, and another one should circumstances demand it.

Dia. of cyl. in inches.	Capac'y of hoist or cyl. in lbs. Air at compressor taken at 80 lbs. per square inch.	Cubic feet of free air required for a lift of 1 foot high.	Dia. of cyl. in inches.	Capac'y of hoist or cyl. in lbs. Air at compressor taken at 80 lbs. per square inch.	Cubic feet of free air required for a lift 1 of foot high.
4	830	0.56	9	4500	2.86
5	1400	0 88	10	5650	3.54
6	2000	1.27	12	8150	5.08
7	2750	1.73	14	11100	6.93
8	3620	2.26			

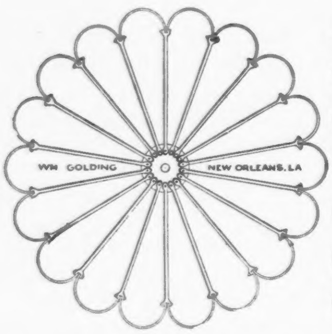
* * *

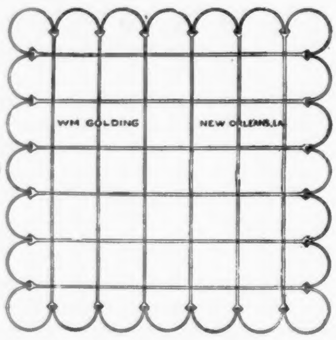
WHEN you happen to be putting up a line of shafting and come to making the connections with couplings, just remember that somebody may have to take it down some day and that this "somebody" may be yourself. There are couplings on the market which one man can put on in good shape, but which take two to get them off. When they are made right they don't need a sledge-hammer to take them down.

ITEMS OF MECHANICAL INTEREST.

NOVEL TANK CONSTRUCTION.

We give below illustrations of two forms of tanks of the construction invented by Mr. Wm. Golding, of New Orleans, La., in which cross-bracing is the main feature. This plan makes each half circle of about five feet radius, the circular tank being braced from a central support, the other from side to side.

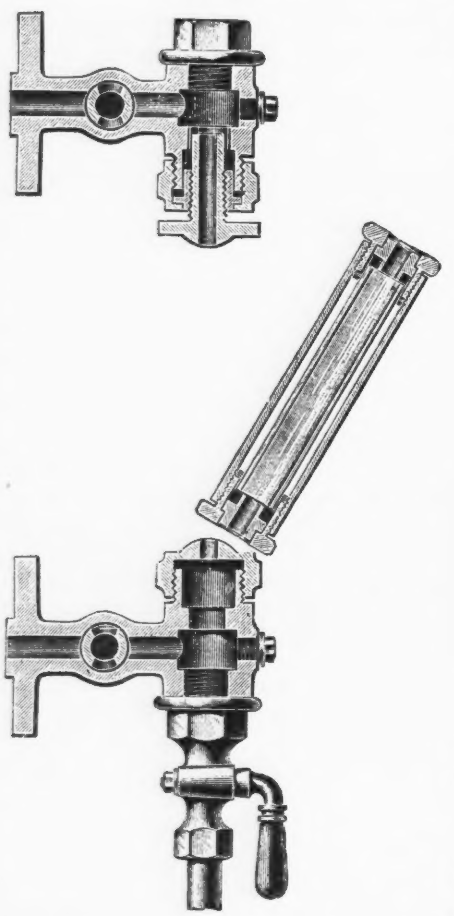




This plan was devised to meet the demand for storage tanks in the vicinity of New Orleans, in which to allow the mud to settle before being used by the city. If, as stated, the daily supply of 8 000 000 gallons contains 50 tons of mud, the necessity is apparent.

WATER GAUGE GLASS.

L'Ingenieur shows a gauge glass system in which the glass is certainly very easily removed or renewed, but which, it would seem, puts quite a strain on the angle fixtures at top and bottom. These are flanged, however, in accordance with European practice, and are better able to stand the strain than the screwed connections in general use in this country. It is novel, but it does not seem as though it would be advisable to use this method on high pressure work. The idea is credited to Th. Maas.



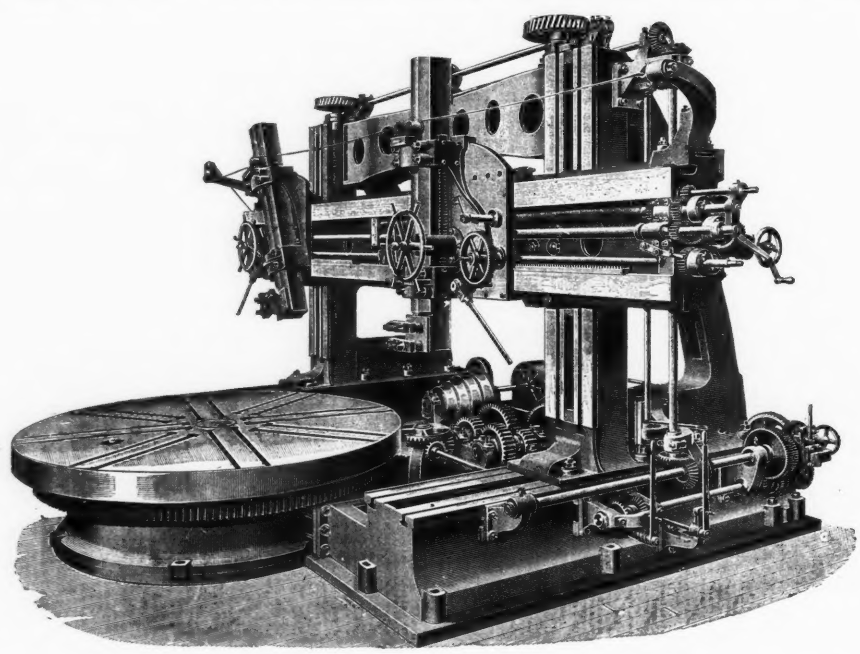
ASPHALT FOR SHOP FLOORS.

For the sake of cleanliness and to obviate the necessity of the frequent repairs necessary for wooden floors in shops, other materials are frequently tried. Concrete makes an excellent floor in appearance and in durability and can be readily laid in the best form to produce perfect drainage. The effect upon workmen is, however, injurious, for the reason that the material is a better conductor of heat than wood is, and therefore draws too much heat in cold weather from the feet of the workmen, and makes them unnecessarily uncomfortable. Concrete is also hard and unyielding and is injurious to the feet on this account. Manufacturers who have put concrete floors into their shops have shortly noticed these effects and have been obliged to cover the floors with boards or to put in planks on supports for the men to stand on at their work, raising the machines the necessary amount to enable this to be done. The loose planks or the stands are rather unsightly and much in the way in moving about and in cleaning up. Asphalt properly mixed to give a smooth and springy surface would seem to be the ideal floor. It is almost, if not quite, as good in appearance as concrete, can be readily laid in any desired form to permit of perfect drainage and facility in cleaning up; can be made as elastic as desired, and become more satisfactory to stand upon than wood; and is a poor conductor of heat, so that it will make it quite as warm a floor as wood. The mixture should not be as stiff as that for street purposes, as the wear is not so great and the variations in temperature are less. Where there is much oil dripping from machines, special pains should be taken to catch the oil, or the floor directly under the machine should be of concrete or other material so arranged as to drain the oil away from the asphalt.—*Municipal Engineering.*

A LARGE BORING MILL.

Although our European cousins insist on calling this a "horizontal lathe," they have evidently succeeded in turning out a very creditable looking machine. It was built by Mr. Ernst Schiess, of Dusseldorf-Oberbilk, and as a consequence all the dimensions are given in the metric system. In round numbers, however, this is a 24½ foot mill, with a face plate 13 feet 1½ inches in diameter. The housings are adjustable and are moved back for any size over 16½ feet.

A 15 HP. motor running at 480 revolutions drives the table,

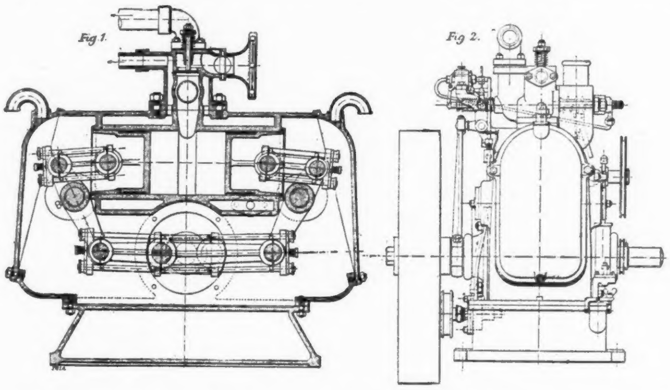


the gearing being so complete that any desired speed can be obtained. Another motor, of 10 HP., moves the housings and cross-rail to the desired positions. The machine weighs 10 tons and is apparently a well designed tool.

CAPITAINE OIL ENGINE.

We illustrate herewith a two-piston balanced type of petroleum engine as made by Messrs. Tolch & Co., of 146 Clerkenwell Road, London, E. C., in which two pistons are used working in opposite directions in a single cylinder, as shown in Fig. 1. Owing to this arrangement the working parts are completely balanced, and vibration reduced to a minimum. The cranks, it will be seen, work in a closed chamber, to which access can be obtained by removing the end cover shown in Fig. 2. Sufficient oil is poured into this chamber to insure the proper lubrication of the whole engine. The petroleum used is gasified by passing it through the cast iron vaporizer, which is heated by means of a lamp. The oil supply in the feed tank is kept under a slight air pressure by means of a pump, worked by the engine. From this tank the oil is led to a valve, through which the oil is admitted to the vaporizer, where it is instantly gasified. To control the

supply of oil to this valve, a second slide valve is used, the position of which is controlled by springs. One of these, mounted on the exhaust valve spindle, tends to keep it closed, while the other is able to move the valve over as soon as the pressure of the former is relieved by the opening of the exhaust valve. The air supply is drawn into the cylinder through the valve shown at the top of the engine in Fig. 1 by the pistons moving outwards from each other. On the return stroke, the mixture of air and petroleum vapor thus formed is compressed into the explosion chamber shown below the air valve in Fig. 1, and thence into the heated vaporizer, which fires the explosive mixture at the end of the compression stroke. After the working stroke, the products of combustion are passed out through an exhaust valve worked by the eccentric rod shown to the left in Fig. 2. As, however, this rod is moved up and down with every revolution of the engine, while the valve requires to be open only at the end of every explosion, a hit-and-miss device is provided, consisting essentially



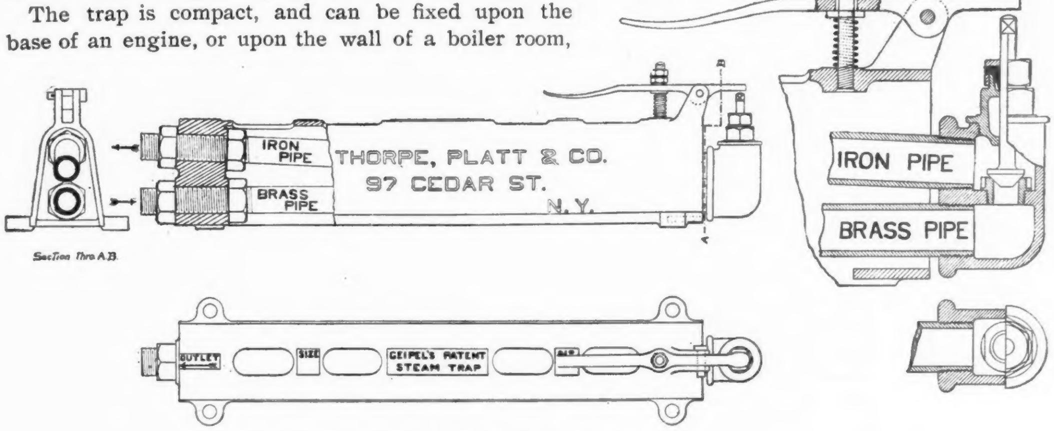
of an 8-toothed ratchet wheel which is rotated through one tooth at every revolution of the engine. On the same axis as this wheel, and moving with it, is a square, and according as an angle or face of this square is presented to the exhaust valve motion, the latter hits or misses the valve spindle. The governing is effected by using a weighted pawl to move the ratchet wheel. Should the speed exceed a certain limit, the inertia of this weight causes the pawl to miss the wheel, which accordingly remains unmoved in such a position that the tappet misses the exhaust valve. The products of combustion remaining in the cylinder, no fresh charge can be drawn in through the air and petroleum valves.

* * *

A NEW STEAM TRAP.

The working of this trap will be clearly seen from the illustration. In its normal cool position, the valve box is down and the valve open; when steam enters the lower pipe it causes it to expand; this raises the valve box and valve, the latter comes in contact with the lever and is closed. Owing to the manner in which the expansion parts are arranged, a very small expansion of the lower brass tube produces a large movement of the valve, closing it rapidly before steam reaches it.

The trap is compact, and can be fixed upon the base of an engine, or upon the wall of a boiler room,



A NEW STEAM TRAP.

without occupying valuable space. It appears to be very accessible, and the valve can be readily removed and examined. The only working part to this trap is the valve, which can be seen to rise and fall as the trap performs its duties. By pressing down upon the lever the resistance to the valve opening is removed and a simple means is thus afforded of blowing through when necessary.

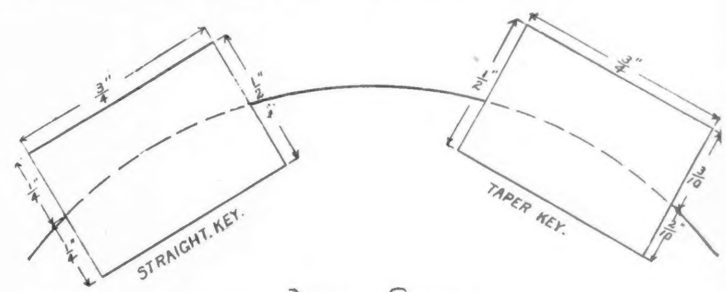
The trap consisting of only two tubes, there is no place in which scale or dirt can lodge. It will work equally well in any position, and if placed upside down will drain entirely dry; therefore it cannot freeze. The appliance is made by Thorpe, Platt & Co., 97 Cedar street, New York.

* * *

HOW AND WHY.

A COLUMN INTENDED TO CONTAIN CORRECT ANSWERS TO PRACTICAL QUESTIONS OF GENERAL INTEREST. GIVE ALL DETAILS AND YOUR NAME AND ADDRESS, WHICH WILL NOT BE PUBLISHED UNLESS DESIRED.

22. A. C. R. asks about keys, both straight and taper, and wants to know what the common practice is in proportioning them. *A.* We give an extract from the catalogue of Baker Brothers, of Toledo, O., who build key-way cutters and do a large amount of this work, believing their conclusions to be a



3-INCH-SHAFT.

practical guide in this matter. The cut gives the dimensions recommended by them for a 3-inch shaft:

The width of the key should equal one-fourth diameter of shaft.

The thickness of the key should equal one-sixth diameter of shaft.

The depth in hub for a straight key-way should be one-half thickness of key.

The depth in hub at large end, for a taper key-way, should be three-fifths thickness of key.

Standard taper for all key-ways should be 3-16 inches in 1 foot of length.

The depth to be cut in hub for taper key-ways, at large end, is greater than those cut straight, for the reason that unless this was done the depth in hub at small end would not be sufficient, especially in long key-ways.

The depths of key-ways in our table are given in thousandths of an inch, corresponding to the graduations on the index plate of our micrometer depth gauge, and is measured from the edge of key-way, and not from the center. In this manner the exact depth of key-way can be measured at any time after it is cut.

For extra long key-ways the depth cut in hub might be slightly increased, but for the average run of work the table will be found correct.

23. E. P. P. asks: 1. Do crank-pins on stationary engines wear out of round? I have never known the journals of center crank engines worn out of true. *A.* The crank-pins wear out of round because the pressure on them is not equal at different points in the stroke. For example, in all modern engines the pressure in the cylinder is highest at the beginning of the stroke, being no more than, perhaps, one-quarter as great at the termination. A little reflection will show how this produces unequal friction and hence unequal wear on the pin. For similar reasons the main journals will wear out of round; but because these journals have greater wearing surfaces and usually a larger permanent load, the effect is not so noticeable. 2. I have been repairing a twin engine, cylinders 8 x 12 inches, running 150 revolutions per minute. They were sold for 15 horse power each, but the builders say that they could be just as well run at 250 revolutions,

the pair developing 50 horse power. Now, I want to ask, why buy a 50 horse power engine when a 30 horse power can be speeded up to do the same work? *A.* An engine is very frequently bought too large for the work, in the expectation of having more work for it. Then, to save fuel, the engine is run slow till considerable more work is added, when it is speeded up. Whether the engine could be satisfactorily speeded up to 250 revolutions will depend upon its construction. H.

* * *

WHAT MECHANICS THINK.

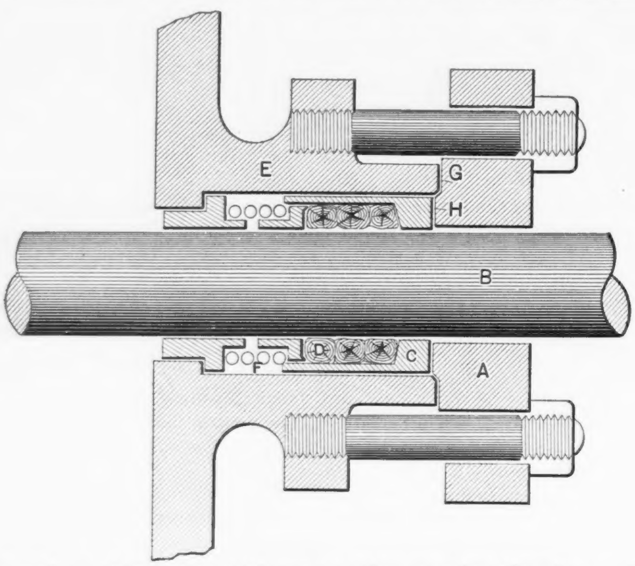
THIS COLUMN IS OPEN FOR THE EXPRESSION OF PRACTICAL IDEAS OF INTEREST, TECHNICAL OR OTHERWISE. WRITE ON ONE SIDE OF THE PAPER ONLY, AND BOIL IT DOWN.

WHEN SKETCHES ARE NECESSARY TO ILLUSTRATE THE IDEA, SEND THEM ALONG—NO MATTER HOW ROUGH THEY MAY BE, WE WILL SEE THAT THEY ARE PROPERLY REPRODUCED.

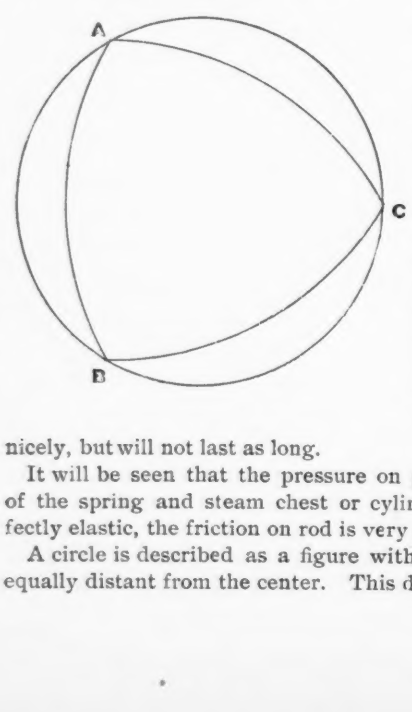
ROD PACKING.

A careful engineer always pays considerable attention to his valve stem and piston-rod packing, especially with the common gland and stuffing-box arrangement. If the gland is not screwed up tight the stem will leak, and if too tight the packing is soon destroyed and stem or rod badly fluted, so that it soon becomes almost a daily job to pack around.

The Fallbrook Railway have the form of stuffing-box and gland shown in drawing, on a number of their locomotives, and



have also put it on the stationary engine running the shops. It gives excellent results, 50 per cent. saving in packing being a low estimate, and the wear of valve stems and piston-rods is reduced to a minimum. Valve stems running eighteen months continuously have shown a reduction of only $\frac{1}{32}$ inch in diameter. The vertical engines of a Shea locomotive equipped with it ran fifteen months with the addition of one ring of packing, and was still apparently in good shape.



The gland A is bored $\frac{1}{4}$ inch large for stem and has a ground joint at G on end of stuffing-box and also at H, for the brass sleeve C. This sleeve is turned $\frac{1}{8}$ inch smaller than bore of stuffing-box for clearance, and is a loose fit on valve stem. The packing D is held in the sleeve by the follower and coiled spring F. Three rings of black lead composition are used; two will do nicely, but will not last as long.

It will be seen that the pressure on packing is limited to that of the spring and steam chest or cylinder, and as this is perfectly elastic, the friction on rod is very slight.

A circle is described as a figure with the outside everywhere equally distant from the center. This does not necessarily mean that a piece of work which will caliper the same all around is perfectly round. The one who indulges in this belief will to his grief, find that another form will gauge equally all around the circumference and still be no more round than of a grain of buckwheat.

Step off around the figure three equally distant points, A, B and C. From these as centers in turn, strike arcs connecting each of the other two points. This figure is far from being round, but it will caliper the same at every point. Lathes with defective spindles are likely to turn a modified form of this figure.

Practical applications for many of the leading propositions of geometry can be found in every-day shop practice, and the boy who makes such application renders a somewhat dry study full of interest.

Corning, N. Y. FRED E. ROGERS.

WIDE BELTS AGAIN.

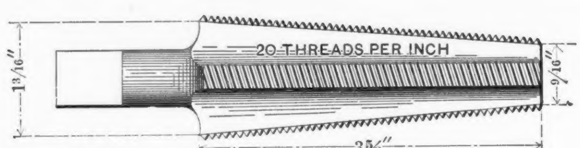
We take the following from a letter from an experienced engineer, who does not care to disclose his identity at present:

"Many of Mr. Grimshaw's tests, from his own account, are made at excessive tensions, tensions which are impossible in practice—no one cares what effect width of belt has in such cases. Now coming down to the long-continued practical tests recorded in the transactions of the A. S. M. E., we find they not only do not show the effect claimed by Mr. Grimshaw, but, properly interpreted, they show exactly the opposite.

"Mr. Grimshaw admits Mr. Cheney's main point, that high speed is best, but adds that width is also good. This can only mean that the ideal design will have first the highest practicable belt speed, and second, that the cross section necessary at that speed shall have the maximum practicable width. That is, Mr. Grimshaw's ideal is a wide, thin, high speed belt, while the tests referred to call for a thick, narrow high speed belt, the cross-section being the same in each case. Both ways cannot be right, and no engineer will admit that any tests not executed under working conditions and carried on for years, should be allowed much standing as against the tests to which I have referred. "BELTS."

A SUGGESTION.

I saw recently a taper tap put to a new use, viz., the enlargement of holes in boiler plate $\frac{3}{8}$ inch thick. I understand that it



works well and is frequently used for the enlargement of holes wherever necessary. I send sketch of same, with dimensions, number of threads, etc. A. H.

WHO KNOWS?

Messrs. Holden & Brooke, Ltd., St. Simon's Works, Salford, Eng., write: "Could any of your readers kindly give a recipe for making whitewash so that the yellow stains from old beams and walls will not come through. In the case in question these stains have come through four coats."

[We are informed that by pasting white paper over the stained portions and whitewashing over it, stains will not show through and the paper will not show under the whitewash. Possibly some of our readers may be able to give other methods.—ED.]

* * *

THE date for holding the second annual convention of the National Association of Manufacturers, has been fixed for the 26th, 27th and 28th of January, 1897, at Philadelphia, Pa.

It is expected that this convention will be one of unusual interest, as the President will submit a report of the first full year of practical work in the lines mapped out by the original convention held in Cincinnati, O., January 1895.

* * *

MANUFACTURERS' NOTES.

THE HOPPES MANUFACTURING CO. report a large increase in orders for their live steam feed-water purifiers and exhaust steam heaters, during the past few weeks. These include over 7,000 HP. of apparatus from widely separated points—Iowa, Missouri, Wisconsin, Florida and South Dakota, being among the States represented.

REPORT to the Engineer Maintenance of Way by the supervisor of signals, on a leading trunk line shows most satisfactory results obtained with a water-proof graphite grease manufactured by the Joseph Dixon Crucible Company, Jersey City, N. J. At one point, from October 1 to November 28, one-quarter pound of the water-proof graphite grease was used on locks, cranks and compensations on outside and on machine in tower. The cost of putting on was little more than oil. The same test was made at another point on the road with the same good result. The supervisor found the water-proof graphite grease better than any other kind of lubricant, as it can be applied quickly and stays where it is put; it is also clean and the water has no effect upon it. Therefore, the supervisor strongly recommends the use of this grease for all the places named above. As the graphite used in the manufacture of this grease is Dixon's pure flake graphite, the lubricating qualities are easily understood, and if the water-proof qualities are all the manufacturers claim and the tests seem to demonstrate, its economy and usefulness for all bearing and exposed parts of railway signals are very evident.

PROBABLY no other among the many unique businesses conducted in the city of New York, is better known than the Manufacturers' Advertising Bureau. This concern was established in 1879 by its present head and proprietor, Benj. R. Western, formerly publisher of the *Engineering and Mining Journal*, the *Manufacturer and Builder*, and *Coal and Iron Record*, all of New York. Its purpose is the management of the newspaper work and advertising for manufacturers who desire this important branch of their business handled in a systematic and profitable way. Its long connection and intimate relations with the trade press in all parts of the United States and representing every industry, enable it to bring to its work an experience and knowledge that insures the best possible results. The present location of the Manufacturers' Advertising Bureau is 126 Liberty Street.

* * *

BUSINESS.

NO CHARGE IS MADE FOR THE INSERTION OF BONA FIDE ITEMS UNDER THE ABOVE HEAD. FOR FURTHER PARTICULARS, ADDRESS THIS OFFICE.

WE have an inquiry from abroad concerning machinery for making cardboard boxes.

* * *

FRESH FROM THE PRESS.

The "Mechanical World" Pocket Dairy and Year Book for 1897. Emmot & Co., Ltd., Manchester, England.

This is the tenth year of publication for this useful little pocket-book, which must meet with favor at home as the first edition is 22,000 copies. The idea of combining a reference book with a dairy is a novel one and should be appreciated by engineers and mechanics generally. The present issue contains much new matter and seems to be thoroughly up to date, the very complete index making it easy to refer to any desired subject.

Principles of Mechanism. Stillman W. Robinson, C. E., D. Sc. John Wiley & Sons, New York. 320 pages, 353 figures. Price, $3.00.

The author's name puts aside all doubt as to reliability, and the student or mechanic, of an inventive turn of mind, will find this almost invaluable. It is a treatise on the modification of motion by means of the elementary combinations of mechanisms or of the parts of machines, and aims to treat the whole subject of mechanism in such a systematic way that, with its aid, any machine may be analyzed. It is impossible to give a fair idea of such a book in a brief review, but we feel sure that anyone who is interested in the designing or operation of mechanical motions, will find in this more real information than exists in any other book on the subject.

Waterbury Machine Co., Waterbury, Conn. Catalog of Wire Drawing machinery.

This little catalog is full of information concerning the Bolton Patent Wire-Drawing machinery and swaging machinery, which is interesting to mechanics generally and especially to those engaged in this line of work. The Standard Wire Gauges in use in the United States, are given and are convenient for reference.

Curtis & Curtis, Bridgeport, Conn. Catalog of Pipe Cutting and Threading machinery.

The machinery made by this firm is too well known to need extended description. The Forbes Patent Die Stocks and other tools have been improved and brought thoroughly up-to-date, leaving little to be desired in this line.

* * *

ADVERTISING LITERATURE.

THE STANDARD SIZES FOR CATALOGS ARE 9X12, 6X9 AND 3½X6 INCHES. THE 6X9 IS RECOMMENDED, AS THIS SIZE IS MOST LIKELY TO BE PRESERVED.

ALFRED BOX & Co., Front and Poplar Streets, Philadelphia, Pa. Catalog of Cranes and Drills. 60 pages, 7½ x 10¾ inches.

A very neat catalog and one which those having use for cranes (and few shops do not need them), will do well to look over carefully.

It includes about all the varieties of cranes needed by the shop or power-house, from the Box patent hand-hoist to jib and traveling cranes. These are fitted with roller bearings, making it easy to handle them with or without load. Their line of radial drills is also shown, which will be of interest to shop men.

THE JOSEPH DIXON CRUCIBLE Co., Jersey City, N. J. Catalog of graphite products.

This has an artistic lithographed cover, and contains a list of their products with illustrations of most of them. These are more than one would expect to find, showing the enterprise of this concern. There is also considerable information regarding the value of graphite as a lubricant.

ALMY WATER-TUBE BOILER Co., 178 Allen's Ave., Providence, R. I. Catalog of boilers.

This is a 24 page catalog, giving the details of the design and manufacture of the Almy Water-Tube boiler, its dimensions, advantages and other interesting information. These are essentially high-pressure boilers, being designed for 250 pounds pressure, and are tested at 400 pounds hydrostatic pressure before leaving the works. Almy's Automatic Feed-Water Regulator is also shown.

MESSRS. W. A. CROOK & BROS. Co., of Newark, N. J., have in press their 1897 catalog.

It will consist of 130 pages, liberally illustrated and showing all the latest improvements in hoisting engines adapted for every purpose. The catalog will cover the entire field in this class of machinery. Applications for the new work will be received now by the W. A. Crook & Bros. Co., and copies sent out as soon as possible after publication.

POPE MFG. Co., Hartford, Conn. Pad calendar.

The twelfth annual issue of the Columbia Pad Calendar has made its appearance in more pleasing form than ever before, having scattered through its daily leaves many attractive illustrations, with an appropriate thought or verse for each day in the year. Among the topics are bicycling, outdoor life, and good roads. The cycling fraternity, to say nothing of the general public, has acquired a decidedly friendly feeling for the Columbia Calendar, and its annual advent is always looked forward to with interest and pleasure. The calendar can be obtained for five two-cent stamps by addressing the Calendar Department of the Pope Manufacturing Company at Hartford, Conn.

THE ASHTON VALVE Co., 271 Franklin St,, Boston, Mass. Wall calendar.

The card portion is a reproduction of the picture where one youngster is telling another some wonderful news. In this case the news is: "It's a go, sure pop," which should remind steam users of the Ashton Pop Safety Valves.

WALWORTH M'F'G Co., 14-24 Oliver Street, Boston, Mass. Pad calendar.

This is one of the handy pad calendars for the desk, having ample room for daily memoranda, as well as historical data which will prove interesting.

NEW YORK CENTRAL & HUDSON RIVER R.R.

The Trip of Prince Michel Hilkoff, Imperial Minister of Ways and Communications of Russia, is the title of another interesting little booklet issued by the New York Central & H. R. R.R. It describes the trip of the Russian Minister from New York to Buffalo, and contains much of general interest concerning the well known route, including some of the equipment of this railroad. It also contains the picture of the Prince and his party, never before published. They can probably be obtained by addressing Geo. H. Daniels, G. P. A., Grand Central Station, New York, and enclosing three 2-cent stamps.

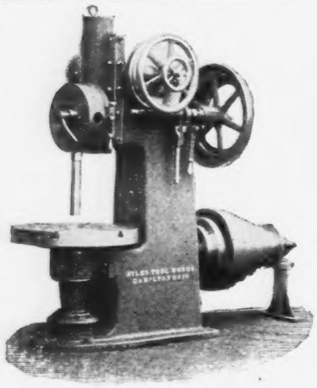
* * *

MACHINERY'S REGISTER.

We have quite a complete list of mechanics in various branches of the trade who, judging by the references given, would be valuable men for any shop needing their services. We will mail the names of five men of the kind desired, with their qualifications and references, on receipt of four cents in stamps. In looking around for men to handle your increasing business we think this list will be of value to you.

Feb. 1897

C



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can do more boring than a lathe. Your shop has enough boring to keep one of these machines busy.

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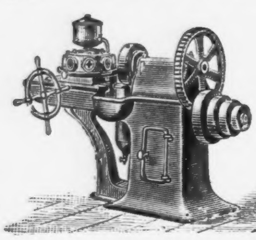

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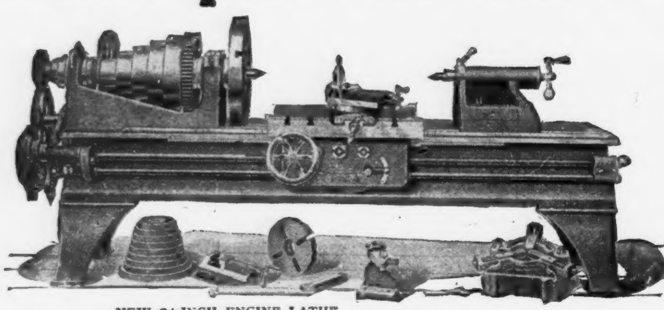

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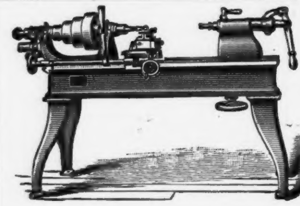

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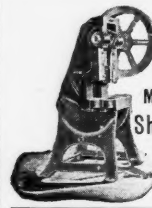

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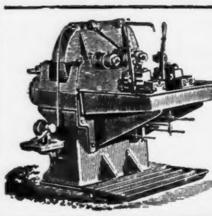

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Two styles. .. Four sizes.
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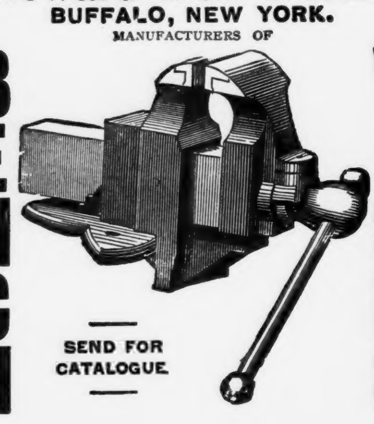

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